SPINNING AND WEAVING CALCULATIONS

N. REISER

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WITH SPECIAL REFERENCE TO WOOLLEN FABRICS

BY

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TRANSLATED FROM THE GERMAN BY

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PREFACE.

The author was prevailed upon to undertake the present work by the solicitation of readers of his earlier treatises. However, though the frequent inquiries for a book of this kind indicated its necessity, the difficulty of the task was equally apparent; and, in fact, it seemed clear from the outset that there was no possibility of setting up any universal standard of costs. For, even though in many respects—such as concern the raw materials, washing, carbonising, milling, raising, spinning, weaving, drying, shearing, pressing, etc.—the conditions are nearly the same for all manufacturers, the factors governing the result of the actual calculations are of a most diversified character. The best foundation for the requisite calculations and reflections is naturally the experience gained in practice; and it is easy for the manufacturer to establish from his account books the most reliable indications respecting the general expenses incurred and the various contingencies to be provided for.

This circumstance, however, does not in the least diminish the utility of the present work, it being of prime importance to the manufacturer to know what calculations should be made and how they are to be performed; and to clearly elucidate these points is the sole object of the present work.

In the performance of his task the author has been guided throughout by a desire to be as complete and as clear as possible. This entails the mention of much that is already a matter of common knowledge to the old hand, though essential for the understanding of the student and the beginner. This reason may also be urged in excuse of sundry repetitions introduced to save too many cross references.

The pains he has taken embolden the author to hope his work will meet with the same friendly recognition as his other writings; more especially as it deals with one of the sorest points in the entire Textile Industry. It is also hoped that the book will be found a reliable guide and helper to those engaged in that industry, especially in the woollen branch.

Finally, the book should act as a warning to many manufacturers to return to more accurate methods of calculating, and cease the reckless cutting of prices. The results of such a course would be to save them from impending ruin, and enable them to conciliate the operatives—thus avoiding discredit on that side also. That the book may exercise a beneficial influence in this direction in particular, is the sincere wish of

N. R.

AACHEN,
January, 1903.

TRANSLATOR'S NOTE.

THE German edition appeared last year, and the author has since revised the figures, especially those dealing with Cloth Calculations, for this translation. In arranging the English edition it has seemed advisable to make certain modifications in the yarn No.'s, etc., stated in the specimen calculations, so as to simplify the figures by avoiding the fractions that would be entailed by giving the exact English equivalents of the metric numbers, German coinage, and so on.

C. S.

LONDON,
May, 1904.

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INTRODUCTION.

THE VALUE OF CALCULATION IN THE TEXTILE INDUSTRY.

In order to work at a profit nowadays, the manufacturer must not merely be possessed of technical knowledge, but must also be able to calculate properly and make a practice of so doing.

Moreover, mere skill as an arithmetician is not sufficient; the manufacturer must also be fully acquainted with the factors with which he has to reckon in his calculations.

Innumerable pieces of badly made goods and countless bankruptcies could have been avoided by an increased ability and willingness in calculation on the part of manufacturers and their subordinates. The manufacturer who does his calculating badly or carelessly injures not himself alone, but also his competitors. As a result of his inaccuracy the price of his finished products grows lower and lower every day, so that finally, despite all possible economies, there is no profit left.

Many manufacturers who either do not know how to work their calculations properly, or else are too easy-going to do so with accuracy, follow the lead of their competitors. How often is it said, "Oh, if so-and-so can do it at the price, I can too"—and then, when the books are made up at the end of the year, the error of this assumption is manifested. In fact, a very large number of such careless workers do not know whether they have made a profit or the reverse until the yearly balance sheet is made up.

Formerly it was the custom to make the goods first and then reckon up the cost; but nowadays one is compelled as a rule to do the calculating first, the permissible limit of cost being well known.

Of all branches in the textile industry, that of woollen goods presents the greatest difficulties in respect of calculation, both as regards the raw material itself and the cost of production. In the former event we have to deal with the cost of and loss in washing; then come the expense and waste in spinning; the cost of weaving, and the count of the warp and weft threads; in the finishing process there are the cost and waste, and the contraction of the finished cloth, the whole being conjoined to furnish the cost of the final product.

In the following chapters the calculation of woollen goods will be chiefly borne in mind, since it will be comparatively easy to deduce from the particulars the necessary conclusions for application to other branches of the industry, more especially because in these latter the losses in respect of waste and contraction are smaller than with wool.

The most convenient course is to divide the calculations into four headings, namely:—

I. Raw material.
II. Yarn.
III. Working calculations.
IV. Piece goods.

SECTION I.

CALCULATIONS CONCERNING THE RAW MATERIAL AND THE YARN.

CHAPTER I.

CALCULATING THE RAW MATERIAL.

In connection with the raw material, we have to deal with three kinds of calculations, namely:—

1. What will be the cost of the wool in the finished state, sorted, washed and carbonised, the percentage of waste and the rate of wages being known?

2. The proportion in which several kinds of wool can be blended in order to obtain a material at a given price.

3. The determination of the quantity of material required to furnish a given length or number of pieces of finished product.

Calculating the Cost of Sorted, Washed and Carbonised Wool.

Example 1.—Assuming that the wool costs 8d. per lb. in the grease, and loses 60 per cent. in scouring, *i.e.*, every 100 lb. yield 40 lb. of scoured wool.

The cost of scouring at Verviers, where this industry is largely carried on, is 8 centimes per kilogramme, which is equivalent to 0·352d. per lb. when the yield is less than 40 per cent. or 0·88d. per lb. in excess of 40 per cent. Carbonising costs 0·88d. per lb. of finished material, and the total cost of sorting, scouring and carbonising amounts to 1·43d. per lb.

Now as the wool loses 60 per cent. in scouring, the remaining 40 per cent costs as much as the original lb. Hence since

40 per cent. of 1 lb. of scoured wool costs 8d.
1 ,, ,, ,, ,, $8 \div 40$, and
100 ,, ,, ,, ,, $(8 \times 100) \div 40 =$
1s. 8d. per lb.

Add to this the cost of scouring, sorting and carbonising, *viz.*, 1·43d., and the cost of the finished wool is 1s. 9½d. per lb.

EXAMPLE 2.—Assuming a 3000 lb. parcel of dirty wool (at 6½d. per lb.) to be in question, and that the same being already sorted has merely to be scoured and carbonised, the loss in this case being taken at only 56 per cent. The first question arising is the quantity of clean wool left, the cost of scouring as a whole and average per lb., and what is the cost per lb. of the scoured wool.

The loss in scouring and carbonising being 56 per cent., we have 44 per cent. of clean wool left, *i.e.*, of the 3000 lb. we have $(44 \times 3000) \div 100 = 1320$ lb.

The cost of scouring has already been given as 0·352d. per lb. up to a yield of 40 per cent. and 0·88d. per lb. in excess of that figure. We have therefore to ascertain how many pounds have to be charged at each rate. Since—

Each 100 lb. of wool in the grease furnish 40 at 0·352d. per lb. for washing.

Each 1 lb. of wool in the grease furnishes $40 \div 100$ at 0·352d. per lb., and 3000 lb. will furnish $(40 \times 3000) \div 100 = 1200$ lb. at 0·352d. per lb.

Accordingly, these 1200 lb. cost 35s. 3d. for scouring. The difference between this quantity and the total 1320 lb., *viz.*, 120 lb., will cost at the rate of 0·88d. per lb. for scouring, or altogether 8s. 9d.

The cost of carbonising 1320 lb. at 0·88d. per lb. is 96s. 9d., and the total cost of the 3000 lb. of wool in the grease was 1625s.

Hence we have the following items of cost :—

	£	s.	d.
Raw wool - - - - -	81	5	0
Scouring 1200 lb. at 0·352d. per lb. -	1	15	3
,, 120 lb. at 0·88d. per lb. -	0	8	9
	£83	9	0

or 1s. $3\frac{1}{8}$d. per lb.

Calculating the Proportion of Different Grades of Wool to Furnish a Mixture at a Given Price.

Example 1.—It is required to produce a mixed wool costing 1s. $1\frac{1}{4}$d. per lb. from two grades in stock costing respectively 1s. $5\frac{1}{2}$d. and 10d. per lb. What proportion of each must be taken?

For this purpose we must employ the formula :—

$$\frac{\text{Desired cost of mixture} - \text{Price of cheapest grade}}{\text{Price of dearest grade} - \text{Price of cheapest grade}}.$$

This resolves itself into $\frac{13{\cdot}25 - 10}{17{\cdot}5 - 10} = \frac{3}{7}$, that is to say, three-sevenths of the mixture must consist of the dearer grade and four-sevenths of the cheaper. Thus, if we take 3 lb. of the wool at 1s. $5\frac{1}{2}$d., costing 4s. $4\frac{1}{2}$d., and 4 lb. of the wool at 10d., costing 3s. 4d., we have 7 lb. of wool costing 7s. $8\frac{1}{2}$d., or 1s. $1\frac{1}{4}$d. per lb.

Example 2.—From stocks costing respectively 1s. $1\frac{1}{4}$d. and $8\frac{3}{4}$d. per lb. to prepare a mixture costing 11d. per lb.

On the basis of the formula already given, we have the proportion $\frac{11 - 8\frac{3}{4}}{13\frac{1}{4} - 8\frac{3}{4}} = \frac{1}{2}$, that is to say, 1 lb. of the wool at 1s. $1\frac{1}{4}$d. and 1 lb. of that at $8\frac{3}{4}$d. give us 2 lb., costing together 1s. 10d., or 11d. per lb.

Example 3.—In many cases the blend consists of three or even more grades. If we take the case of three grades costing respectively 1s. 8d., 1s. 4d. and 10d. per lb., and desire to produce a mixture costing 1s. 2d. per lb. and containing 1s. 4d. worth of the medium grade of wool in each 10 lb. of the mixture, we must proceed as follows :—

The proportion of middle grade wool is thus fixed at 1 lb., leaving 9 lb. to be apportioned between the other two.

Then 10 lb. of wool at 1s. 2d. will cost 11s. 8d.
1 ,, ,, ,, 1s. 4d. ,, 1s. 4d.

leaving 9 lb. to cost 10s. 4d.

On making this quantity up to 10 lb. at the same rate, we have 10 lb. costing 10s. 4d. + 13·8d. = 137·8d., or 13·78d. per lb. Taking now the same formula as at first, we have $\frac{13\cdot78 - 10}{20 - 10} = \frac{3\cdot78}{10}$, that is to say, in every 10 lb. of a mixture of these two there would have to be 3·78 lb. of the higher grade wool and 6·12 lb. of the cheaper quality. As, however, we only require 9 lb. of such mixture to make up the 10 lb. (there being 1 lb. of the medium wool), these figures must be correspondingly reduced by one-tenth, *i.e.*, we obtain 3·4 lb. as the requisite quantity of high grade wool and 5·6 lb. of the cheapest wool for our mixture.

That these quantities will furnish the desired result is evident from the following calculations :—

Medium wool	at 1s. 4d.	1 lb.	1s. 4d.
Dearest grade	at 1s. 8d.	3·4 lb.	5s. 8d.
Cheapest grade	at 10d.	5·6 lb.	4s. 8d.
Total . .		10 lb.	11s. 8d., or 1 lb. at 1s. 2d.

EXAMPLE 4.—In this case we will take four grades of wool at the following prices :—

I. quality at 1s. 8d. per lb.
II. ,, ,, 1s. 1d. ,,
III. ,, ,, 11d. ,,
IV. ,, ,, 10d. ,,

from which to compose a blend costing 1s. per lb.

There are several ways of doing this, the most convenient being to first calculate a mixture of the first and third sorts, and then a corresponding mixture of the second and fourth, the two being afterwards mixed in equal proportions.

The first equation will then be $\frac{12-11}{20-11}=\frac{1}{9}$, *i.e.*, the first mixture will consist of 8 parts of the cheaper wool (III.) and one part of the dearest (I.).

For the second mixture the formula gives us $\frac{12-10}{13-10}=\frac{2}{3}$, or bringing the fraction to the same denominator as in the first mixture $\frac{6}{9}$, *i.e.*, this second mixture will require to be composed of three parts of the cheaper component (IV.) and six of the dearer (II.). If we take these parts as pounds we have the following proportions :—

	s.	d.
1 lb. of No. I. wool at 1s. 8d. .	1	8
6 ,, ,, II. ,, 1s. 1d. .	6	6
8 ,, ,, III. ,, 11d. .	7	4
3 ,, ,, IV. ,, 10d. .	2	6
18 ,, of final mixture costing .	18	0, or 1s. per lb.

Calculating Quantity of Material Required for Producing a Given Length or Number of Pieces of Cloth.

Example 1.—The first problem we will take is to calculate the quantity of raw wool required to produce 40 yds. of cloth 67 inches wide inside the selvages (each 1 inch) and woven with a reed of 15 dents to the inch, each dent taking 4 ends.

The warp yarn is to run 10,000 yds. to the lb., and the weft 9090 yds. per lb.; number of picks, 62½ to the inch. The loss sustained by the wool in scouring is assumed to be 56 per cent. and in spinning 3 per cent., and the contraction of the warp and weft in the loom 6 per cent. and 4 per cent. respectively.

With 15 four-end dents per inch and a breadth of 67 inches of cloth, the total length of yarn in each yard of full width of warp threads will be $15 \times 4 \times 67 = 4020$ yds.

Now each warp suffers a greater or smaller amount of con-

traction during the operation of weaving in the loom, the actual extent depending on a variety of factors. Thus :—

1. On the varying degree of tension imparted to the warps in the loom.

2. On the thickness of the weft yarns.

3. On the hardness or softness of the weft yarn. The softer the weft the smaller the effect of flexion it exerts on the warp, and therefore the less will the latter contract. The converse equally applies.

4. On the mode of intersection of the threads. The result will differ according to :—

(*a*) The number of intersections in a given length of warp or number of picks, and

(*b*) Whether the same warp thread has to cross one or more weft threads (see later).

The percentage of contraction ranges from 2 to 10 and even 12 per cent., according as the weft is fine, soft or thick, one or more layers of weft have to be crossed, and according to the tension put upon the warps. In the present instance the contraction is assumed to be 6 per cent., and therefore the aforesaid 4020 yds. of yarn will only be 94 per cent. of the total requirement.

Hence we must reckon that as—

94 per cent. of the total warp length is					4020 yds.
1	,,	,,	,,	,,	$4020 \div 94$.
and 100	,,	,,	,,	,,	$(4020 \times 100) \div 94$
					$= 4277$ yds. of yarn.

The yarn runs 10,000 yds. per lb. Hence 1 yd. will weigh 0·0001 lb., and 4277 yds. will weigh 0·4277 lb.

The number of picks being $62\frac{1}{2}$ per in., there will be $62\frac{1}{2} \times 36 = 2250$ picks per yd.; and since the width of the cloth is 67 in., plus 2 in. of selvage, *i.e.*, 69 in., these 2250 picks will consume $(2250 \times 69) \div 36 = 4312\frac{1}{2}$ yds. of weft yarn per yard of cloth.

A very large number of manufacturers and textile experts stop the calculation of the weft at this stage, and make no allowance for contraction. This factor, however, must be borne in mind, because whilst the spinner tests the fineness

of his weft yarns under tension, in order to make the count as high as possible (seeing that the price increases with the fineness), the conditions are different in the loom despite all attempts to subject the yarn to artificial tension, this being particularly the case when the shuttle rebounds a little on entering the box. As already mentioned, we make in the present instance an allowance of 4 per cent. for weft contraction, and therefore the above length of weft will have to be increased accordingly.

Then, since 96 per cent. of the actual requirements of weft equals $4312\frac{1}{2}$ yds., 1 per cent. of the actual requirements of weft equals $4312\frac{1}{2} \div 96$, and 100 per cent. of the actual requirements of weft will be $(4312\frac{1}{2} \times 100) \div 96$, *i.e.*, 4492 yds.

Since the weft yarn runs 9090 yds. to the pound, each yard weighs 0·00011 lb., and therefore the total weight of yarn required per yard of cloth will be : $4492 \times 0{\cdot}00011 = 0{\cdot}49412$ lb. or in round figures $\frac{1}{2}$ lb.

The total weight of warp and weft yarn required per yard of cloth is therefore :—

Warp 0·43 lb.
Weft 0·49 lb.

0·92 lb.

An allowance has now to be made of 3 per cent. for waste in spinning, this being made up of fluff in carding and fine spinning, broken ends and other sources of loss. Hence the aforesaid 0·92 lb. of wool represents only 97 per cent. of the total required, which will therefore be $(0{\cdot}92 \times 100) \div 97 =$ 0·948 lb. This figure in turn has to be augmented to allow for the loss in scouring, namely, 56 per cent., so that the 0·945 lb. represents only 44 per cent. of the total amount of wool in the grease, *viz.* $(0{\cdot}945 + 100) \div 44 = 2{\cdot}15$ lb. per yd.

Hence for 40 yds. of cloth there will be needed $40 \times 2{\cdot}15$ lb. $= 86$ lb. of raw wool.

A few units per cent. in addition may be allowed for waste of yarn in weaving.

Example 2.—Take as material a mixture of wool 50 per

cent., shoddy 35 per cent. and mungo 15 per cent. The wool costs 1s. 2d. per lb. and loses 35 per cent. in scouring; the shoddy costs $8\frac{3}{4}$d. per lb., and the mungo $5\frac{1}{2}$d. The loss in spinning averages 10 per cent. all round. The problem is to find the cost of a 40-yd. piece of cloth prepared from these materials and weighing 20 oz. per yard, allowing 12 per cent. for loss of material in milling, raising and shearing.

The yard of cloth is to weigh 20 oz., and as the loss in finishing is 12 per cent., these 20 oz. represent only 88 per cent. of the total weight of raw material, which will therefore be $(20 \times 100) \div 88 = 22\frac{3}{4}$ oz. per yard.

Since the raw material has lost 10 per cent. in spinning, the $22\frac{3}{4}$ oz. represent merely 90 per cent. of the total, and must be correspondingly increased, *viz.* $(22\frac{3}{4} \times 100) \div 90 = 25\frac{1}{4}$ oz. per yard.

To take the wool first. As this comprises 50 per cent. of the mixture, the weight per yard will be 12·625 oz., and as it has lost 35 per cent. in scouring, the amount of wool to be taken in the grease will be $(12{\cdot}625 \times 100) \div 65 = 19\frac{1}{2}$ oz. for each yard of cloth, or $40 \times 19\frac{1}{2}$ oz. = 48 lb. for the 40 yds. at the stated price of 1s. 1d. per lb.; this gives the cost of the raw wool as £2 12s.

The shoddy comprises 35 per cent. of the total $25\frac{1}{4}$ oz. of material required, *i.e.*, $8\frac{7}{8}$ oz., making for the 40 yds. a total of 22 lb., which at $8\frac{3}{4}$d. per lb. gives 16s. as the cost of the shoddy.

Finally the yarn also contains 15 per cent. of mungo or $3\frac{3}{4}$ oz. per yard, making in the 40 yds. $9\frac{1}{2}$ lb., which at $5\frac{1}{2}$d. per lb. comes to 4s. 4d. as the cost of the mungo.

Consequently, the cost of the total raw material will be as follows:—

	£	s.	d.
Pure wool . . .	£2	12	0
Shoddy	0	16	0
Mungo	0	4	4
Total	£3	12	4

Since where inferior material is worked an additional 5 per cent. should be allowed for waste ends, etc., in the weaving the raw material will cost altogether about £3 16s.

SECTION I. (*Continued*).

CHAPTER II.

THE YARN.

THE calculation of yarns being of a very divergent character may be divided into groups, *viz.*:—

1. The cost of yarn from a given material.
2. Calculating a yarn or twist, to determine the yarn number.
3. Calculating the cost of twist.
4. Determining the yarn number for a given kind of cloth.
5. Determining the weight of a yard of cloth, the yarn number and setting of warp and weft being known.
6. Ascertaining the quantity of yarn required for a given kind of cloth.
7. What length of yarn to beam, the weight being known.

COST OF YARNS FROM A GIVEN MATERIAL.

For the price of the raw material, see the preceding chapter.

For the cost of spinning, including wages, olein, or other oil, and waste in spinning, the following figures may be taken as averages :—

Spinning Woollen Yarns.

The spinning of	yarn	running	1000	yds.	to the	lb. costs	1·8d.
,,	,,	,,	1500	,,	,,	,,	1·9d.
,,	,,	,,	2000	,,	,,	,,	1·98d.
,,	,,	,,	2500	,,	,,	,,	2·06d.
,,	,,	,,	3000	,,	,,	,,	2·15d.
,,	,,	,,	3500	,,	,,	,,	2·23d.
,,	,,	,,	4000	,,	,,	,,	2·31d.
,,	,,	,,	4500	,,	,,	,,	2·4d.

The spinning of	yarn	running	5000	yds.	to the	lb. costs	2·48d.
,,	,,	,,	5500	,,	,,	,,	2·56d.
,,	,,	,,	6000	,,	,,	,,	2·64d.
,,	,,	,,	6500	,,	,,	,,	2·83d.
,,	,,	,,	7000	,,	,,	,,	3·02d.
,,	,,	,,	7500	,,	,,	,,	3·21d.
,,	,,	,,	8000	,,	,,	,,	3·40d.
,,	,,	,,	8500	,,	,,	,,	3·59d.
,,	,,	,,	9000	,,	,,	,,	3·78d.
,,	,,	,,	9500	,,	,,	,,	3·97d.
,,	,,	,,	10000	,,	,,	,,	4·18d.
,,	,,	,,	10500	,,	,,	,,	4·37d.
,,	,,	,,	11000	,,	,,	,,	4·56d.
,,	,,	,,	11500	,,	,,	,,	4·75d.
,,	,,	,,	12000	,,	,,	,,	4·94d.

Yarns woven for sale are usually oiled in the following proportions :—

(*a*) Cheviot wools and various mixtures, 14 per cent. of olein.
(*b*) Ordinary wools, 10 ,, ,,

Where the yarn is spun for weaving on the premises, the percentage of oil averages 5 to 7 per cent.

The olein fluctuates considerably in price, but the average may be taken as about 21s. per cwt., or $2\frac{1}{4}$d. per lb.

It may be taken for granted that, after storage for some time, the weight of olein in the oiled yarn diminishes by about 50 per cent.

The manufacturer who gives his yarns out to be spun should not be too niggardly with regard to the rate paid, or it may lead to the spinner employing cheap and unsaponifiable oiling material. Such a misguided cutting of prices may result in bitter disappointment when the goods come to pass through the finishing process, dirty and malodorous pieces being the logical consequences of such policy.

Loss in Spinning Woollen Yarns.

With pure wool the loss is nil ; in fact there is an increase in weight if the wool be good and properly treated. This gain

is, however, merely an apparent one, since there is invariably a loss of fibre, in the form of fluff, ends and dust, in the carding and spinning processes, though this weight is more than counterbalanced by the olein added. As is well known, it is usual to mix the olein with soap and water, a little sal-ammoniac being added to improve the miscibility. A portion of this added water evaporates already in the carding process, more in roving, and a further quantity in fine spinning, especially when the air is warm. The aforesaid drying of the olein to a decrease of 50 per cent. in weight takes some time to accomplish, so that if the spinner delivers his yarn as soon as spun he will have a greater weight than if he waits a few days.

This circumstance also explains why certain spinners of woollen and worsted yarns always store their output in cellars with stone or cemented floors, the air and floor being humidified daily when necessary. When treated in this manner the yarn does not dry, but often actually increases in weight.

The purchaser of yarn has a very good weapon against this peculiar method of loading the material, by submitting the samples to a conditioning house for the determination of the contained moisture.

The permissible limits of moisture in the various textile materials are as follows:—

Wool, woollen yarns and woollen goods .	17 per cent.
Cotton, cotton yarns and cotton goods .	8 to $8\frac{1}{4}$,,
Hemp, hemp yarns and hemp goods . .	$11\frac{1}{2}$ to 12 ,,
Flax, linen yarns and linens . . .	$7\frac{1}{2}$,,
Jute yarns and goods	$11\frac{1}{2}$,,
China grass, yarns and goods . . .	7 ,,
Silk yarns and silk goods	11 ,,

When goods or yarns of mixed fibres are in question, the percentage constitution of the mixture must be taken into account.

In point of loss during spinning, good mixtures, *e.g.*, of wool and good shoddy, behave about the same as wool by itself; inferior mixtures lose about 5 to 8 per cent.

Mixtures of shoddy, broken ends, mungo, cotton, etc., suffer

a diminution of 10 to 20 per cent. according to the shortness of staple in the raw material and the time the yarn has been stored in a more or less dry state. In any case the manufacturer will do well not to underestimate this shrinkage, since it is almost invariably present.

EXAMPLE 1.—Take the case of a mixture of

Sidney wool, 360 lb., at 2s. $2\frac{1}{2}$d. per lb.
Clean Silesia wool, 240 lb., at 2s. $3\frac{1}{2}$d. ,,

to be spun into warp yarn measuring 10,000 yds. per lb. What will the yarn cost per lb., reckoning the general expenses at 8 per cent. and 4s. for carriage of the materials?

		£	s.	d.
1 lb. of Sidney wool costs 2s. $2\frac{1}{2}$d.	. 360 lb. =	£39	15	0
1 lb. of Silesia wool ,, 2s. $3\frac{1}{2}$d.	. 240 lb. =	27	10	0
	600 lb.			
Deduct for waste and ends .	4 lb.			
Net weight of yarn . . .	596 lb.			
8 per cent. of olein for oiling 600 lb., 48 lb. at $2\frac{1}{4}$d.		0	9	0
Cost of spinning 596 lb. at 4·66d. per lb. .		11	6	6
Cost of cartage		0	4	0
		£79	4	6
Less waste, 4 lb. at 9d. . . .		0	3	0
		£79	1	6
General expenses and profit, 8 per cent. .		6	6	6
		£85	8	0

Hence 1 lb. of yarn will cost 2s. $10\frac{3}{8}$d.

EXAMPLE 2.—The mixture consists of

195 lb. of white wool	(60 per ct. of the mixture)	at 1s. $10\frac{1}{2}$d.	per lb.
49 lb. of worsted ends	(15 ,, ,, ,,)	,, 11d.	,,
20 lb. light Thibet	(6 ,, ,, ,,)	,, 6d.	,,
61 lb. light flannel	(19 ,, ,, ,,)	,, 5d.	,,

and is to be spun to warp yarn running 6350 yds. to the lb.

At what price can this yarn be sold, allowing 3s. for cartage and 8 per cent. for general expenses?

		£	s.	d.
The 195 lb. of white wool at 1s. $10\frac{1}{2}$d. cost	.	£18	5	10
49 lb. ,, worsted ends at 11d. ,,	.	2	5	9
20 lb. ,, Thibet at 6d. ,,	.	0	10	0
61 lb. ,, flannel at 5d. ,,	.	1	5	5
325 lb.		£22	7	0
Less 5 lb. waste.				
Net 320 lb. of yarn.				
10 per cent. of olein, $32\frac{1}{2}$ lb. at $2\frac{1}{4}$d.	.	0	6	1
Cost of spinning 320 lb. at 3d.	.	4	0	0
Cartage	.	0	3	0
		£26	16	1
Less waste, 5 lb. at $2\frac{3}{4}$d.	.	0	1	2
		£26	14	11
General expenses and profit, 8 per cent.	.	2	3	1
		£28	18	0

or 1s. 10d. per lb.

EXAMPLE 3.—Take the following mixture:—

$72\frac{1}{2}$ lb. Danish wool cleanings	at $5\frac{1}{2}$d. per lb.	£1	13	4
75 lb. coarse white wool	,, $9\frac{1}{2}$d. ,,	2	19	4
5 lb. mixed wool	,, $5\frac{1}{2}$d. ,,	0	2	4
57 lb. black cotton carding ends	,, $7\frac{1}{8}$d. ,,	1	13	10
109 lb. carbonised mixed mungo	,, $3\frac{1}{4}$d. ,,	1	9	6
54 lb. ,, drab mungo	,, $3\frac{1}{4}$d. ,,	0	14	8
3 lb. ,, coarse mixed mungo	,, $2\frac{1}{2}$d. ,,	0	0	8
$84\frac{1}{2}$ lb. opened inferior ends	,, $3\frac{1}{4}$d. ,,	1	4	8
$61\frac{1}{2}$ lb. mixed fluff	,, $4\frac{1}{2}$d. ,,	1	3	0
85 lb. dark ,,	,, $4\frac{1}{2}$d. ,,	1	11	11
$24\frac{1}{2}$ lb. coloured ends	,, $3\frac{7}{8}$d. ,,	0	8	0
85 lb. mixed waste	,, $2\frac{1}{2}$d. ,,	0	17	9
716 lb.		£13	19	0

from which it is desired to produce a yarn running 4080 yds.

to the lb. What will the yarn cost per lb., allowing 5s. 6d. for cartage and 6 per cent. for general expenses?

		£	s.	d.
The total cost of the 716 lb. of material is		£13	19	0
Less waste and ends	22 lb. at $1\frac{1}{8}$d.	0	2	2
Net yarn	694	£13	16	10
10 per cent. of olein, $71\frac{1}{2}$ lb. at $2\frac{1}{4}$d.		0	13	6
Cost of spinning 694 lb. of yarn at 2·4d.		6	18	10
Cartage		0	5	6
		£21	14	8
General expenses and profit, 6 per cent.		1	5	4
		£23	0	0

or 8d. per lb.

Calculating the Yarn Number.

Although between the year 1874 and the present time no less than six international conferences have been held for the purpose of establishing uniformity in the numbering of yarns, no result has yet been achieved. There is, however, some probability of an agreement being arrived at in the near future.

Broadly speaking, the numbering of yarns may be approached from two points of view: the ratio of the length of a yarn to the weight being taken as the basis in one case, and that of the weight to the length in the other.

As mentioned above, the day is probably not far distant when the metric system of numbering yarns will be generally adopted; at all events, this is desirable for industrial and commercial convenience. The metric or decimal system is based on the number of metres going to the kilogramme of yarn (2·2 lb.). (An exception is made in the case of silk, because here a smaller weight must be taken as the basis or unit.) Thus, if 20,000 metres of a yarn go to the kilogramme, the yarn will be No. 20 and so on.

Existing Systems of Numbering Yarns.

(*a*) *Cotton Yarn.*—Except in France, the English system of numbering is universally employed. This consists in the number of hanks, each of 840 yds., going to 1 lb. of yarn.

(*b*) *Flax or Linen Yarn.*—The English system, namely the number of leas or cuts of 300 yds. each going to the lb.

(*c*) *Jute Yarn.*—The English system is used, and is on the same basis as for flax yarn.

(*d*) Nettle fibre, China Grass and Ramie are numbered on the metric or decimal system.

(*e*) *Silk.*—The unit of weight is 50 milligrammes (known as the international denier), the unit of length being 500 metres.

(*f*) Chappe and waste silk yarns are numbered like worsted yarn or on the decimal system.

(*g*) *Woollen Yarn.*—Here a distinction is drawn between carded (woollen) and combed (worsted) yarn.

Carded Woollen Yarn.—The English system is based on the number of hanks (560 yds.) going to the lb.

In and around Berlin the count is based on the number of pieces (Stück) to the pound of 500 grammes. Each piece consists of 4 leas (Gebinde) of 880 threads (Faden) of 2200 Berlin ells (1604·35 yds.).

In Saxony the basis of numbering is called a Zahl, of which there are three kinds :—

No. 1.	1	Zahl	5	Gebinde	400	Faden	800	Leipzig ells	(of $22\frac{1}{4}$ ins.)
2.	1	,,	4	,,	320	,,	800	,,	,,
3.	1	,,	5	,,	400	,,	1200	,,	,,

Here also the yarn No. is the number of Zahlen per lb. of 500 grammes.

In Austria 1 Strahn (hank) equals 20 Gebinde, 800 Faden or 1760 Viennese ells of 77·8 cm. ($30\frac{1}{2}$ ins.), the standard weight being the old Viennese lb. of 560·012 grammes (1·232 lb.).

In France two systems are current, that of Elbeuf and that of Sedan.

2

In Elbeuf, 1 hank = 40 cuts = 1800 threads = 3600 metres (3937 yds.)

In Sedan, 1 hank = 22 cuts = 968 threads = 1493 metres (1632 yds.)

Worsted Yarn.—Except in England, where the system is the same as for woollen yarn, worsted is numbered on the decimal system.

Mohair, alpaca and camel hair yarns being still mainly produced in England, are numbered on the English system the same as woollen yarn.

Twists are numbered in the same way as the yarns of which they are composed, the number varying in accordance with the number of plies in the twist.

Example 1.—Assume two single yarns of equal thickness, *viz.*, No. 56, to be twisted together, the resulting twist will be $56 \div 2 =$ No. 28. There is no need to make any allowance for contraction in twisting in this case, the material being so elastic that if the ordinary strong tension be exerted in doubling no shortening will occur.

If, however, two yarns of different count be taken, the calculation is different. Nevertheless a simple formula enables the twist number to be determined.

Take, for instance, a No. 72 single yarn and another single, No. 45, and double them to twist. The formula will be :—

$$\frac{72 \times 45}{72 + 45} = \text{No. } 27{\cdot}692.$$

When three singles are united to a twist the calculation is first made with two, and the result is calculated with the third.

Example 2.—If three singles numbered 50, 36 and 18 respectively be taken for twisting, any two can be calculated together first. Supposing these to be the two lower numbers, the formula runs :—

$$\frac{36 \times 18}{36 + 18} = 12.$$

This is then calculated with the third :—

$$\frac{50 \times 12}{50 + 12} = \text{No. } 9{\cdot}677.$$

EXAMPLE 3.—In practice it often happens that a twist of given count, say No. 24, is to be produced by doubling a yarn of given count, say No. 36, with another the count of which has to be calculated.

This problem is solved by a simple formula, namely, by multiplying the number of the given single yarn with the number of the desired twist, and dividing the product by the difference between them. In our example the formula will run :—

$$\frac{36 \times 24}{36 - 24} = \text{No. } 72.$$

EXAMPLE 4.—When it is a question of forming a twist from three yarns, the numbers of two of which are known, the number of the third is found by treating the two known numbers according to the preceding rule, and then treating the result in accordance with the last rule, *i.e.*, the two rules are combined.

Assuming a twist No. 20 has to be compounded from three singles, one being No. 72 and another No. 56, whilst the number of the third component has to be calculated, then the formulæ will be :—

$$1.\ \frac{72 \times 56}{72 + 56} = \text{No. } 31{\cdot}5.$$

$$2.\ \frac{31{\cdot}5 \times 20}{31{\cdot}5 - 20} = \text{No. } 54\tfrac{3}{4}.$$

On a subsequent page tables are given showing the twist numbers produced by doubling two singles of equal or different count.

CALCULATING THE COST OF TWIST YARNS.

The spinner frequently has to estimate the cost of twist yarns produced from singles of different counts.

EXAMPLE 1.—Where the two singles are equal in count and price the cost of the twist is the same as that of the singles, increased by the cost of doubling. This may be illustrated by the following simple instance: if the single yarn costs 3s. 9d.

TWIST NUMBERS OBTAINED BY DOUBLING

Doubling together Nos.	1	2	3	4	5	6	7	8	9	10	11	12
	Gives Twist Number.											
1	0·5	0·666	0·75	0 8	0·833	0·857	0·875	0·888	0·9	0·909	0·917	0·923
2	0·666	1·000	1·200	1·333	1·428	1·500	1·555	1·600	1·636	1·666	1·692	1·714
3	0·75	1·200	1·500	1·714	1·875	2·000	2·000	2·181	2·250	2·307	2·357	2·400
4	0·8	1·333	1·714	2·000	2·222	2·400	2·545	2·666	2·769	2·857	2·933	3·000
5	0·833	1·428	1·875	2·222	2·500	2·727	2·666	3·076	3·214	3·333	3·437	3·529
6	0·857	1·500	2·000	2·400	2·727	3 000	3·230	3·428	3·600	3·750	3·882	4·000
7	0·875	1·555	2·100	2·545	2·916	3·230	3·500	3·733	3·937	4·118	4·277	4·421
8	0·888	1·600	2·181	2·666	3·076	3·428	3·733	4·000	4·118	4·444	4·631	4·800
9	0·9	1·636	2·250	2·769	3·214	3·600	3·937	4·235	4·500	4·736	4·950	5·142
10	0·909	1·666	2·307	2·857	3·333	3·750	4·118	4·444	4·736	5·000	5·238	5·454
11	0·916	1·692	2·357	2·933	3·437	3·882	4·277	4·631	4·950	5·238	5·500	5·739
12	0·923	1·714	2·400	3·000	3·529	4·000	4·421	4·800	5·142	5·454	5·739	6·000
13	0·928	1·733	2·437	3·058	3·611	4·105	4·550	4·952	5·318	5·652	5·958	6·240
14	0·933	1·750	2·470	3·111	3·684	4·200	4·666	5·090	5·478	5·833	6·160	6·461
15	0·937	1·764	2·500	3·157	3·750	4·285	4·772	5·217	5·625	6·000	6·346	6·666
16	0·941	1·777	2·526	3·200	3·809	4·363	4·870	5·333	5·760	6·153	6·518	6·857
17	0·944	1·789	2·550	3·238	3·863	4·434	4·958	5·440	5·885	6·296	6·678	7·034
18	0·947	1·800	2 571	3·272	3·913	4·500	5·040	5·539	6·000	6·428	6·827	7·200
19	0·95	1·809	2·590	3·303	3·958	4·560	5·115	5·629	6·107	6·551	6·966	7·354
20	0·952	1·818	2·608	3·333	4·000	4·615	5·185	5·714	6·206	6·666	7·096	7·500
21	0·954	1·826	2·625	3·360	4·038	4·666	5·250	5·793	6·300	6·774	7·218	7·636
22	0·956	1·833	2·640	3·384	4·074	4·714	5·310	5·866	6·387	6·875	7·333	7·764
23	0·958	1·840	2 653	3·407	4·107	4·758	5·366	5·935	6·468	6·969	7·441	7·885
24	0·96	1·846	2·666	3·428	4·137	4·800	5·419	6·000	6·545	7·058	7·543	8·000
25	0·961	1·851	2·678	3·448	4·166	4·838	5·468	6·060	6·617	7·142	7·638	8·108

Two Equal or Dissimilar Single Numbers.

13	14	15	16	17	18	19	20	21	22	23	24	25
Gives Twist Number.												
0·928	0·933	0·937	0·941	0·944	0·947	0·950	0·952	0·954	0·956	0·958	0·96	0·961
1·733	1·750	1·764	1·777	1·789	1·800	1·809	1·818	1·826	1·833	1·840	1·846	1·851
2·437	2·470	2·500	2·526	2·550	2·571	2·590	2·608	2·625	2·640	2·653	2·666	2·678
3·058	3·111	3·157	3·200	3·238	3·272	3·303	3·333	3·360	3·384	3·407	3·428	3·448
3·611	3·684	3·750	3·809	3·863	3·913	3·958	4·000	4·038	4·074	4·107	4·157	4·166
4·105	4·200	4·285	4·363	4·434	4·500	4·560	4·615	4·666	4·714	4·758	4·800	4·838
4·550	4·666	4·772	4·869	4·958	5·040	5·115	5·185	5·250	5·310	5·366	5·419	5·468
4·925	5·090	5·217	5·333	5·440	5·539	5·629	5·714	5·793	5·866	5·935	6·000	6·060
5·318	5·478	5·625	5·760	5·885	6·000	6·107	6·206	6·300	6·387	6·468	6·545	6·617
5·652	5·833	6·000	6·153	6·296	6·428	6·551	6·666	6·774	6·875	6·969	7·058	7·142
5·958	6·160	6·346	6·518	6·678	6·827	6·966	7·096	7·218	7·333	7·441	7·543	7·638
6·240	6·461	6·666	6·857	7·034	7·200	7·354	7·500	7·636	7·764	7·885	8·000	8·108
6·500	6·740	6·964	7·172	7·366	7·548	7·718	7·878	8·029	8·171	8·305	8·432	8·552
6·740	7·000	7·241	7·466	7·677	7·875	8·060	8·235	8·400	8·555	8·702	8·842	8·974
6·964	7·241	7·500	7·741	7·969	8·181	8·382	8·571	8·750	8·918	9·278	9·230	9·375
7·172	7·466	7·741	8·000	8·242	8·470	8·685	8·888	9·081	9·263	9·435	9·600	9·756
7·366	7·677	7·969	8·242	8·500	8·742	8·972	9·189	9·394	9·589	9·775	9·951	10·120
7·548	7·875	8·181	8·470	8·742	9·000	9·243	9·473	9·692	9·900	10·097	10·285	10·465
7·718	8·060	8·382	8·685	8·972	9·243	9·500	9·743	9·975	10·194	10·404	10·604	10·795
7·878	8·235	8·571	8·888	9·189	9·473	9·743	10·000	10·244	10·476	10·697	10·909	11·111
8·029	8·400	8·750	9·081	9·394	9·692	9·975	10·244	10·500	10·740	10·977	11·200	11·413
8·171	8·555	8·918	9·263	9·389	9·900	10·194	10·476	10·740	11·000	11·244	11·478	11·702
8·305	8 702	9·078	9·435	9·775	10·097	10·404	10·697	10·977	11·244	11·500	11·744	11·979
8·432	8·842	9·230	9·600	9·951	10·285	10·604	10·909	11·200	11·478	11·744	12·000	12·240
8·552	8:974	9·375	9·756	10·120	10·465	10·795	11·111	11·413	11·702	11·979	12·240	12·500

TWIST NUMBERS OBTAINED BY DOUBLING

Doubling together Nos.	26	28	30	32	34	36	38	40	42	44	46	48
	Gives Twist Number.											
20	11·304	11·666	12·000	12·307	12·592	12·857	13·103	13·333	13·548	13·750	13·939	14·117
22	11·916	12·320	12·692	13·037	13·357	13·655	13·933	14·193	14·437	14·666	14·882	15·085
24	12·480	12·923	13·333	13·714	14·069	14·400	14·709	14·999	15·268	15·529	15·771	16·000
26	13·000	13·481	13·928	14·345	14·733	15·097	15·437	15·757	16·059	16·343	16·611	16·865
28	13·481	14·000	14·482	14·933	15·353	15·756	16·118	16·470	16·800	17·111	17·405	17·684
30	13·928	14·482	15·000	15·483	15·937	16·363	16·765	17·143	17·500	17·837	18·158	18·461
32	14·345	14·933	15·483	16·000	16·484	16·941	17·371	17·777	18·162	18·526	18·871	19·200
34	14·733	15·353	15·937	16·484	17·000	17·485	17·944	18·378	18·789	19·179	19·550	19·902
36	15·097	15·750	16·363	16·941	17·485	18·000	18·486	18·947	19·384	19·800	20·195	20·571
38	15·437	16·118	16·764	17·371	17·944	18·486	19·000	19·487	19·950	20·390	20·809	21·209
40	15·757	16·470	17·142	17·777	18·378	18·947	19·487	20·000	20·488	20·952	21·395	21·818
42	16·059	16·800	17·500	18·162	18·789	19·384	19·950	20·488	21·000	21·488	21·954	22·400
44	16·343	17·111	17·838	18·526	19·179	19·800	20·390	20·952	21·488	22·000	22·488	22·956
46	16·611	17·405	18·158	18·871	19·550	20·195	20·809	21·395	21·955	22·488	23·000	23·489
48	16·865	17·684	18·461	19·200	19·902	20·571	21·209	21·818	22·400	22·957	23·489	24·000
50	17·105	17·948	18·750	19·512	20·238	20·930	21·590	22·222	22·826	23·404	23·958	24·489
52	17·333	18·200	19·024	19·809	20·558	21·272	21·955	22·608	23·234	23·833	24·408	24·960
54	17·555	18·439	19·285	20·093	20·863	21·600	22·304	22·978	23·625	24·245	24·840	25·411
56	17·756	18·666	19·534	20·363	21·155	21·913	22·638	23·333	24·000	24·640	25·254	25·846
58	17·952	18·884	19·772	20·622	21·434	22·212	22·958	23·673	24·360	25·019	25·654	26·264
60	18·139	19·090	20·000	20·869	21·702	22·500	23·265	24·000	24·705	25·386	26·037	26·666
62	18·318	19·288	20·217	21·106	21·958	22·776	23·560	24·313	25·038	25·736	26·407	27·054
64	18·488	19·478	20·425	21·333	22·204	23·040	23·843	24·615	25·358	26·074	26·763	27·428
66	18·652	19·659	20·625	21·551	22·440	23·294	24·115	24·905	25·666	26·400	27·107	27·789
68	18·808	19·833	20·816	21·760	22·666	23·538	24·377	25·185	25·963	26·714	27·438	28·138

TWO EQUAL OR DISSIMILAR SINGLE NUMBERS—(*continued*).

50	52	54	56	58	60	62	64	66	68	70	72	74
Gives Twist Number.												
14·286	14·444	14·594	14·736	14·872	15·000	15·122	15·214	15·349	15·452	15·555	15·652	15·744
15·277	15·459	15·631	15·794	15·950	16·091	16·238	16·372	16·500	16·622	16·739	16·849	16·958
16·216	16·421	16·615	16·800	16·975	17·143	17·302	17·454	17·600	17·739	17·872	18·000	18·122
17·105	17·333	17·550	17·756	17·952	18·139	18·318	18·488	18·652	18·808	18·959	19·102	19·240
17·948	18·200	18·439	18·666	18·883	19·090	19·288	19·478	19·659	19·833	20·000	20·160	20·313
18·750	19·024	19·285	19·534	19·773	20·000	20·217	20·425	20·625	20·816	21·000	21·176	21·346
19·512	19·809	20·093	20·363	20·622	20·869	21·106	21·333	21·551	21·760	21·960	22·153	22·339
20·238	20·558	20·863	21·155	21·434	21·702	21·958	22·203	22·440	22·666	22·884	23·094	23·296
20·930	21·272	21·600	21·913	22·212	22·500	22·776	23·040	23·294	23·538	23·773	24·000	24·217
21·590	21·955	22·304	22·638	22·958	23·265	23·560	23·843	24·115	24·377	24·629	24·879	25·107
22·222	22·608	22·978	23·333	23·673	24·000	24·313	24·615	24·905	25·185	25·457	25·714	25·964
22·826	23·234	23·625	24·000	24·360	24·705	25·039	25·358	25·666	25·963	26·250	26·526	26·793
23·404	23·833	24·245	24·640	25·019	25·386	25·736	26·074	26·400	26·714	27·017	27·310	27·593
23·958	24·408	24·840	25·254	25·653	26·038	26·407	26·763	27·104	27·438	27·759	28·067	28·366
24·489	24·960	25·411	25·846	26·264	26·666	27·054	27·428	27·789	28·138	28·474	28·800	29·114
25·000	25·490	25·961	26·415	26·851	27·272	27·678	28·070	28·448	28·813	29·166	29·508	29·838
25·490	26·000	26·490	26·963	27·417	27·857	28·280	28·689	29·083	29·466	29·836	30·193	30·539
25·961	26·490	27·000	27·490	27·964	28·421	28·861	29·288	29·700	30·098	30·484	30·857	31·219
26·415	26·963	27·490	28·000	28·491	28·965	29·424	29·866	30·295	30·709	31·111	31·500	31·877
26·852	27·418	27·964	28·491	29·000	29·491	29·966	30·426	30·870	31·301	31·719	32·123	32·515
27·272	27·857	28·421	28·965	29·491	30·000	30·491	30·967	31·428	31·875	32·307	32·727	33·134
27·678	28·280	28·862	29·423	29·966	30·491	31·000	31·492	31·968	32·430	32·878	33·313	33·735
28·070	28·689	29·289	29·866	30·426	30·968	31·492	32·000	32·492	32·969	33·432	33·882	34·311
28·448	29·084	29·700	30·295	30·871	31·429	31·969	32·492	33·000	33·492	33·970	34·435	34·885
28·813	29·466	30·098	30·709	31·301	31·875	32·430	32·969	33·492	34·000	34·492	34·929	35·437

per lb. and the cost of doubling is 3d. per lb., the twist will cost 3s. 9d. + 3d. = 4s. per lb.

EXAMPLE 2.—The case is altered when we have to deal with yarns of different prices. Assuming we have a No. 36 yarn costing 3s. 3d. per lb. and another No. 36 yarn costing 2s. 5d. per lb., what will be the price of a twist composed of these two, when the cost of doubling is 2d. per lb.?

The two singles being of the same count, the twist number will be 36 ÷ 2 = No. 18. And as $\frac{1}{2}$ lb. of each must be taken to furnish 1 lb. of the twist, the price will be

1s. $7\frac{1}{2}$d. + 1s. $2\frac{1}{2}$d. + 2d. = 3s. per lb.

EXAMPLE 3.—The two singles are not always of the same count, it being often necessary to double yarns of different count to form a twist. An instance of this class arises when a No. 72 yarn costing 3s. per lb. has to be doubled with a No. 45 yarn costing 2s. 4d. per lb., and the problem then to be solved is what will be the cost of the resulting twist, the expense of doubling being 3d. per lb.

The first thing is to find the twist number. By the formula already given this will be :—

$$\frac{72 \times 45}{72 + 45} = \text{No. } 27{\cdot}7.$$

The proportion by weight of the finer yarn required to produce the twist will be 27·7 ÷ 72 = 0·384 lb., which at 3s. per lb. will cost . . . . 13·8d.
The lower number will amount to 27·7 ÷ 45 = 0·616 lb., which at 2s. 4d. per lb. will cost . . . . 17·2d.
Cost of doubling . . . . 3·00d.

Total cost per lb. . . . . 2s. 10d.

EXAMPLE 4.—Where three different singles at different prices are in question, the calculation is also easy, though somewhat more complex. Take the yarn numbers and prices at :—

No. 64 at 3s. 1d. per lb.
No. 45 at 2s. 10d. ,,
No. 36 at 2s. 8d. ,,

and the cost of doubling $2\frac{1}{2}$d. per lb., the problem is to ascertain the cost of the resulting 3-ply twist.

The first step is to combine two of the singles, say the two higher numbers. The formula runs :—

$$\frac{64 \times 45}{64 + 45} = \text{No. } 26 \cdot 4.$$

This result is then combined with the third single :—

$$\frac{26 \cdot 4 \times 36}{26 \cdot 4 + 36} = \text{No. } 15 \cdot 25.$$

The resulting 3-ply twist is then No. $15\frac{1}{4}$.

The proportions by weight will be as follows :—

No. 64,	$15 \cdot 25 \div 64 = 0 \cdot 24$ lb.	which at 3s. 1d.	per lb. .	8·88d.
No. 45,	$15 \cdot 25 \div 45 = 0 \cdot 34$ lb.	,, 2s. 10d.	,, .	11·56d.
No. 36,	$15 \cdot 25 \div 36 = 0 \cdot 42$ lb.	,, 2s. 8d.	,, .	13·4d.
	Cost of spinning per lb.	.	. .	2·5d.
	Cost of twist per lb. .	.	. .	3s. $0\frac{3}{8}$d.

SECTION I. (*Continued*).

CHAPTER III.

THE YARN (*continued*).

Calculating the Yarn Number to be used for a Given Kind of Cloth.

In addition to the method of weaving, the yarn number plays an important part in the production of any given kind of cloth, and of this a few instances will now be given.

Example 1.—What yarn number must be taken to produce 1 yd. of finished woollen cloth weighing $18\frac{1}{2}$ oz. including selvages, the width being 68 ins. between selvages, the reed setting 15×4 threads per inch, and the picks $62\frac{1}{2}$ per inch. It is furthermore assumed that the warp and weft yarn will be of the same count; that the contraction of the former will be 6 per cent. and of the weft 5 per cent. in the loom; that the cloth will shrink 10 per cent. in the finishing process and lose 16 per cent. in weight in addition to dressing; and that the weight of the selvages will be $\frac{1}{4}$ oz. per yard.

After deducting the weight of the selvages the net weight of the cloth is $18\frac{1}{4}$ oz., and the loss of weight in finishing has been taken as 16 per cent. of material, oil and dirt, apart from the dressing. Now the dressing (size) is applied to the yarn after spinning, but on the other hand the oil, water and adherent dirt must be weighed together. Allowing for this loss the gross weight of the yarn will therefore be

$$(18\frac{1}{4} \times 100) \div 84 = 21\frac{3}{4} \text{ oz.}$$

The reed has 15 four-end dents to the inch, and therefore there will be 4080 warp threads in the 68 ins. of width or 4080 yds. of warp per yard of cloth. As the shortening of the

warp in the loom is taken as 6 per cent., the gross length of warp required per yard of cloth will be

$$(4080 \times 100) \div 94 = 4340 \text{ yds.}$$

The number of picks being $62\frac{1}{2}$ per inch, there will be 2250 picks in the yard of cloth. Each weft thread is 68 ins. in length plus 2 ins. of selvage, *i.e.*, 70 ins., and therefore the length of weft required per yard of cloth will be $(2250 \times 70) \div 36 = 4375$ yds. In the loom the weft is not subject to such a strong tension as that employed by the spinner when testing the yarn number on the reel, and if an allowance of 5 per cent. be made on this account, the total length of weft required will be increased to $(4375 \times 100) \div 95 = 4605$ yds.

Length of warp required .	4340 yds.
,, weft ,, .	4605 ,,
Total . .	8945 yds. per yard of cloth.

An allowance has still to be made for the shrinkage of the cloth in the finishing process. As this has been fixed at 10 per cent., these 8945 yds. of yarn represent only 90 per cent. of the gross total which will therefore be

$$(8945 \times 100) \div 90 = 9939 \text{ yds. of yarn.}$$

The net weight per yard of cloth is $18\frac{1}{4}$ oz., and therefore the weight of yarn per lb. will be

$$(9939 \times 16) \div 18\tfrac{1}{4} = 8710 \text{ yds. (No. } 15\tfrac{1}{2}).$$

Example 2.—It is required to produce a cloth 72 ins. wide between selvages and weighing 24 oz. per yard with a 20 (six-end) dents reed, the weft count being $119\frac{1}{2}$ picks per inch. The weft is to be $1\frac{1}{2}$ numbers coarser than the warp, and an allowance made of 5 per cent. for weft contraction in the loom and of 16 per cent. for loss of weight in finishing the cloth (exclusive of dressing). Weight of selvage per yard $\frac{1}{4}$ oz. as before. What numbers of warp and weft must be taken?

The selvages weighing $\frac{1}{4}$ oz. the net weight of cloth per yard will be $23\frac{3}{4}$ oz. Since, however, there is a loss of 16 per cent. in weight during the finishing process to be allowed for, this $23\frac{3}{4}$ oz. represents only 84 per cent. of the total weight required, which will therefore be

$$(23\tfrac{3}{4} \times 100) \div 84 = 28\tfrac{1}{4} \text{ oz. per yard.}$$

The reed has 20 six-end dents per inch, so that there will be $20 \times 6 \times 72 = 8640$ warp ends in the full width, or 8640 yds. of warp per yard of cloth.

It is further assumed that the warp suffers a contraction of 7 per cent. in the loom, so that these 8640 yds. represent only 93 per cent. of the total length required, which will therefore be $(8640 \times 100) \div 93 = 9290$ yds. of warp yarn.

The weft count of the cloth is $119\frac{1}{2}$ picks per inch or 4302 per yd., and as the length of each pick is 72 ins. plus 2 ins. of selvage = 74 ins., the length of weft required will be $(4302 \times 74) \div 36 = 8843$ yds. An allowance having, however, to be made for contraction in the loom, namely 5 per cent., the above length must be augmented accordingly, and we thus have $(8843 \times 100) \div 95 = 9308$ yds. as the gross length of weft yarn per yard of cloth.

Length of warp required . .	9290 yds.
,, weft ,, . .	9308 ,,
Total . .	18598 yds.

As there is a shrinkage of 12 per cent. in finishing the cloth, these 18598 yds. represent only 88 per cent. of the total, which will therefore amount to $(18598 \times 100) \div 88 = 21134$ yds.

Now the weight of the finished cloth is to be $24 - \frac{1}{4} = 23\frac{3}{4}$ oz., and therefore since 21134 yds. of the yarn weigh $23\frac{3}{4}$ there will be $(21134 \times 16) \div 23\frac{3}{4} = 14250$ yds. per lb., *i.e.*, No. 25 yarn.

If the warp and weft were to be of the same count yarn the number in each case would be 25, but as there is to be a difference of $1\frac{1}{2}$ between the counts, the weft being the lower number, this difference must be halved, which will give No. $25\frac{3}{4}$ as the count of warp yarn and No. $24\frac{1}{4}$ as the count of weft yarn to be spun.

Example 3.—If the face warp or face weft of any fabric is to be thicker than the rest, the setting must be adjusted accordingly. The case is different, however, when we have to do with the back warp or back weft, *i.e.*, when the goods do not quite come up to the required weight.

Assuming the goods to be strengthened by the use of a No. $15\frac{3}{4}$ back warp, of which there are 3960 ends in the full width of the cloth, and that the finished cloth weighs $22\frac{1}{2}$ oz. per yard, it is desired to bring the weight up to 24 oz. per yard, the entire difference being made up in the back warp so as not to unduly increase the cost, and at the same time leave the warp setting unaltered.

The warp suffers a contraction of 6 per cent. in the loom, a similar shrinkage of 6 per cent. occurring in the finishing process, and a loss of weight to the extent of 12 per cent. The problem is to ascertain what count of back warp must be taken to fulfil these conditions.

Since the contraction in weaving is 6 per cent. and the same in finishing, and the loss in weight is 12 per cent., these two factors counteract each other and are therefore negligible.

The first thing to ascertain is the weight of the 3960 ends of under warp. In No. $15\frac{3}{4}$ yarn 8900 yds. go to the lb., and as we have 3,960 yds. of warp in the yard of cloth these will therefore weigh $(3960 \times 16) \div 8900 = 7\frac{1}{8}$ oz. Hence we shall require $7\frac{1}{8}$ oz. of back warp per yard of cloth, neglecting the contraction and loss of weight.

Now, as already mentioned, the weight of the cloth is to be increased to 24 oz. per yard, and the increase is to be entirely confined to the back warp which must therefore weigh

$$7\tfrac{1}{8} + 1\tfrac{1}{2} = 8\tfrac{5}{8} \text{ oz.}$$

Since $8\frac{5}{8}$ oz. measure 3960 yds. 1 lb. will measure

$$(3960 \times 16) \div 8\tfrac{5}{8} = 7350 \text{ yds. or No. 13 yarn.}$$

This latter, then, is the yarn that must be taken to produce the desired increase in weight.

Example 4.—As a final example we will take the case of a cloth with a No. $8\frac{3}{4}$ back weft. Of this yarn there are 1370 picks per yard of finished cloth, and the width including selvages is 74 ins. The problem is to find what number of yarn to take to increase the weight of the cloth by $2\frac{1}{2}$ oz. per yard. The contraction of the weft in the loom is 6 per cent., and the loss in finishing 20 per cent.

Subtracting the 6 per cent. contraction from the 20 per cent.

loss in finishing, we have a difference of 14 per cent. Hence the $2\frac{1}{2}$ oz. form only 100 − 14 per cent., or 86 per cent. of the total extra weight, which will therefore be

$$(2\tfrac{1}{2} \times 100) \div 86 = 3 \text{ oz.}$$

Each of the 1,370 picks of weft measures 74 ins., or a total length of 2800 yds. per yard of cloth. As, however, the contraction in the loom is 6 per cent., this quantity is only 94 per cent. of the total length required, which will therefore be

$$(2800 \times 100) \div 94 = 3000 \text{ yds.}$$

The next step is to ascertain the weight of back weft now required per yard of cloth. Since No. $8\frac{3}{4}$ yarn measures 4900 yds. per lb., the 3000 yds. will weigh $(3000 \times 16) \div 4900 = 9\frac{7}{8}$ oz.; but as the net weight of the cloth is to be increased by $2\frac{1}{2}$ oz. or 3 oz. gross, the weight of the 3000 yds. has to be $9\frac{7}{8} + 3 = 12\frac{7}{8}$ oz. Hence the required yarn must measure per lb. $(3000 \times 16) \div 12\frac{7}{8} = 3700$ yds., and therefore No. $6\frac{1}{2}$ yarn must be taken.

Calculating the Weight per Yard of Cloth made from Given Counts of Yarn and with a Given Setting of Warp and Weft.

Example 1.—What will be the weight per yard of a cloth made of No. $15\frac{3}{4}$ warp and No. $14\frac{1}{2}$ weft, the width being 68 ins. between selvages, the reed having $16\frac{1}{4}$ dents per inch each containing 4 ends, the weft 70 picks per inch, and the selvage weighing $\frac{1}{4}$ oz. per yard? The warp is assumed to contract 8 per cent. in the loom, the weft 5 per cent., the shrinkage of the cloth in finishing being 9 per cent., and the loss of weight in this process 18 per cent.

The number of warp ends in the full width will be $16\frac{1}{4} \times 4 \times 68 = 4420$ ends, or 4420 yds. of warp per yard of cloth. The contraction of the warp in the loom and the shrinkage in finishing together make $8 + 9 = 17$ per cent., and therefore these 4420 yds. represent only 83 per cent. of the total warp needed which will consequently be

$$(4420 \times 100) \div 83 = 5325 \text{ yds. of warp yarn.}$$

The warp yarn being No. $15\frac{3}{4}$ runs 8800 yds. to the lb., and therefore the above 5325 yds. will weigh

$$(5325 \times 16) \div 8800 = 9{\cdot}66 \text{ oz.}$$

The number of picks being 70 per inch, there will be 70 $\times$ 36 = 2520 picks per yard; but as the cloth shrinks 9 per cent. in finishing, these 2520 picks are only 100 − 9 = 91 per cent. of the total to be woven, *i.e.*, (2520 $\times$ 100) $\div$ 91 = 2770 picks.

Each pick has a length of 68 + 2 ins. (for the selvages) = 70 ins. so that the 2770 picks have a total length of 5386 yds. As, however, the weft contraction in the loom is 5 per cent., this length will have to be correspondingly increased, *i.e.*, to

$$(5386 \times 100) \div 95 = 5670 \text{ yds.}$$

Now No. $14\frac{1}{2}$ yarn runs 8120 yds. to the lb., and therefore these 5670 yds. will weigh (5670 $\times$ 16) $\div$ 8120 = $11\frac{1}{8}$ oz.

Weight of warp yarn per yard of cloth	.	9·66 oz.
,, weft ,, ,, ,,	.	11·12 ,,
Total	. .	$20\frac{3}{4}$ oz.

The cloth, however, is to lose 18 per cent. in weight (apart from the dressing material) in the finishing process, and therefore the total weight must be reduced accordingly, *i.e.*, ($20\frac{3}{4}$ $\times$ 82) $\div$ 100 = 17 oz. Adding $\frac{1}{4}$ oz. for the selvages the net total weight of the cloth will consequently be $17\frac{1}{4}$ oz. per yard.

Example 2.—The problem is to ascertain the weight per yard of woollen cloth from the following data:—

Face warp . . .	No. $15\frac{3}{4}$ yarn
Back warp . . .	,, 8 ,,
Face weft . . .	,, $14\frac{1}{2}$,,
Back weft . . .	,, 8 ,,

The reed contains $12\frac{1}{2}$ six-end dents per inch in the width of 72 in. between selvages, the warps being set 2 to 1, the wefts pick for pick, 55 face picks and as many back picks per inch. The warp contraction in the loom is 6 per cent., and the goods lose 20 per cent. in weight (apart from dressing) in the finishing process.

There being $12\frac{1}{2}$ six-end dents per inch in the reed, the total number of warp ends per 72 ins. of width will be

$12\frac{1}{2} \times 6 \times 72 = 5400$. Now, as stated above, the warp contraction in the loom is 6 per cent., and the goods shrink 10 per cent. in finishing, hence we shall have to take $10 + 6 = 16$ per cent. more warp, *viz.* $(5400 \times 100) \div 84 = 6428$ yds.

Now the warps are set 2 to 1, *i.e.*, two ends of face warp to one of back warp, and therefore these 6428 yds. consist of 4285 of face warp and 2143 of back warp. The face warp is No. $15\frac{3}{4}$ which runs 8800 yds. to the lb., and therefore the 4285 yds. will weigh 7·9 oz. Furthermore, since the back warp is twice as thick as the face warp, and there are only half the number of ends, the weight will also be 7·9 oz.

Since there are 55 picks of face weft and an equal number of back weft per inch, there will be 1980 yds. of each in a yard of the cloth. Take the face weft first. The goods shrink 10 per cent. in finishing, and hence these 1980 picks represent only 90 per cent. of the total to be employed, which will therefore be $(1980 \times 100) \div 90 = 2200$.

Each pick has a length of 72 ins. plus 2 ins. for the selvages, *i.e.*, 74 ins. Hence the 2200 picks will consume 4522 yds. of yarn without making any allowance for weft contraction. The No. $14\frac{1}{2}$ yarn runs 8100 yds. to the lb., and therefore the 4522 yds. will weigh $(4522 \times 16) \div 8100 = 8{\cdot}9$ oz. per yard of cloth.

The length of back weft is the same, *viz.*, 4522 yds., but as this yarn (No. 8) runs 4500 yds. to the lb., this quantity will weigh 1 lb. per yard of cloth.

The quantity of yarn required is therefore as follows :—

Face warp	7·9 oz.
Back warp	7·9 ,,
Face weft	8·9 ,,
Back weft	16 ,,
Total . .	$40\frac{3}{4}$ oz.

In finishing, the goods will lose 20 per cent. of fibre, oil and dirt, and therefore the weight will have to be reduced to this extent, *i.e.* $(40\frac{3}{4} \times 80) \div 100 = 32{\cdot}6$ oz.

Allowing $\frac{1}{4}$ oz. per yard for the weight of the selvage, the total weight of the finished cloth per yard will therefore be $32\frac{3}{4}$ oz.

Example 3.—What will be the weight per yard of a worsted cloth woven in accordance with the following data?

Width 66 ins. between selvages, reed 20 six-end dents per inch, warp No. $63\frac{1}{2}/2$, weft No. $28\frac{1}{4}$ single, weft count $122\frac{1}{2}$ picks per inch. The warp contracts 6 per cent. and the weft 4 per cent. in the loom. The goods shrink 5 per cent. in the length, and lose 8 per cent. by weight in finishing. Weight of selvages $\frac{1}{4}$ oz. per yard.

The reed having 20 six-end dents per inch, there will be $20 \times 6 \times 66 = 7920$ warp ends in the full width, and 7920 yds. per yard of cloth. The warp contraction being 6 per cent. in the loom and 5 per cent. in finishing, a total of 11 per cent., the length of warp yarn required will be

$$(7920 \times 100) \div 89 = 8899 \text{ yds.}$$

The warp is No. $63\frac{1}{2}/2$ which is equal to No. $31\frac{3}{4}$ single, and as the latter runs 17,780 yds. to the lb., the 8899 yds. will weigh $(8899 \times 16) \div 17780 = 8$ oz. per yard of cloth.

The weaver has to insert $122\frac{1}{2}$ picks per inch or 4410 per yard. As the cloth shrinks 5 per cent. in finishing, these picks will have to be increased to a proportionate extent, and will therefore number $(4410 \times 100) \div 95 = 4642$ picks. Each has a length of 66 ins. plus 2 ins. for selvages = 68 ins., and therefore the length of weft yarn to be taken will be

$$(4642 \times 68) \div 36 = 8768 \text{ yds. per yard of cloth.}$$

The allowance for weft contraction in the loom is 4 per cent., and therefore $(8768 \times 100) \div 96 = 9133$ yds. must be taken.

This yarn, being No. $28\frac{1}{4}$, runs 15,800 yds. to the lb., and therefore the above 9133 yds. will weigh

$$(9133 \times 16) \div 15800 = 9\tfrac{1}{4} \text{ oz. per yard of cloth.}$$

Weight of warp ends . . .	8	oz. per yard.
,, weft ,, . . .	$9\frac{1}{4}$	,,
Total . .	$17\frac{1}{4}$	oz.

As, however, the goods lose 8 per cent. in finishing, the final weight will be $(17\frac{1}{4} \times 92) \div 100 = 15\frac{7}{8}$ oz. To this must be added $\frac{1}{4}$ oz. for the selvage, so that the total weight is $15\frac{7}{8} + \frac{1}{4} = 16\frac{1}{8}$ oz. per yard.

Example 4.—What will be the weight per yard of a worsted cloth based on the following data?

Width between selvages 68 ins., reed 20 four-end dents per inch, warp yarn No. 49/2, face weft No. 56/2, back weft No. $9\frac{1}{4}$. Number of picks per inch, face weft 85, back weft, $42\frac{1}{2}$. The warp is assumed to contract 6 per cent. in the loom, the face weft 4 per cent. and the back weft 5 per cent. In addition the cloth shrinks 8 per cent. and loses 18 per cent. in weight in the finishing process. The selvages weigh $\frac{1}{4}$ oz. per yard.

The reed containing 20 four-end dents per inch, and the cloth being 68 ins. wide between selvages, the number of warp ends in the full width will be $20 \times 4 \times 68 = 5440$, or 5440 yds. of warp yarn per yard of cloth. The warp contraction is 6 per cent. in the loom and 8 per cent. in finishing or together 14 per cent. The length of warp must therefore be increased to $(5440 \times 100) \div 86 = 6326$ yds.

The yarn being No. 49/2, which is equal to No. $24\frac{1}{2}$ single, runs 13,720 yds. to the lb., and the 6326 yds. will therefore weigh $(6326 \times 16) \div 13720 = 7\frac{3}{8}$ oz. per yard of cloth.

The number of picks to be inserted per inch is 85 of face weft and therefore 3060 per yard. As the goods shrink 8 per cent. in finishing, the number of face picks must be increased accordingly to $(3060 \times 100) \div 92 = 3326$ per yard.

The length of each pick being 68 ins. plus 2 ins. for the selvage or 70 ins. in all, the 3326 face picks will therefore have a total length of $(3326 \times 70) \div 36 = 6456$ yds. As the face weft contracts 4 per cent. in the loom, these 6456 yds. are only 96 per cent. of the total, *i.e.*, $6456 \times 100 \div 96 = 6725$ yds.

The yarn is No. 56/2, which is equal to No. 28 single, and runs 15,680 yds. to the lb. Consequently the 6725 yds. will weigh $6725 \times 16 \div 15680 = 6\frac{7}{8}$ oz. per yard of cloth.

The number of back picks is only half that of the face picks, *i.e.*, 1540 per yard, the length being $6456 \div 2 = 3228$ yds. per yard of cloth. Here an increase of 5 per cent. must be made for the contraction in the loom, *i.e.*,

$$(3228 \times 100) \div 95 = 3398 \text{ yds. per yard of cloth.}$$

This yarn is No. $9\frac{1}{4}$ single which runs 5180 yds. to the lb., and hence the above 3398 yds. will weigh

$$(3398 \times 16) \div 5180 = 10\tfrac{1}{2} \text{ oz.}$$

The warp yarn weighs . . .	$7\frac{3}{8}$ oz.	per yard	of cloth.
The face weft	$6\frac{7}{8}$	,,	,,
The back weft	$10\frac{1}{2}$	,,	,,
Total . .	$24\frac{3}{4}$ oz.		

The loss of weight in finishing is 18 per cent. mostly applicable to the back weft, and we therefore have only 82 per cent. of the total yarn material left in the finished cloth. Consequently the final weight is $(24\frac{3}{4} \times 82) \div 100 = 20\frac{1}{4}$ oz. per yard, plus $\frac{1}{4}$ oz. the weight of the selvage, or a total of $24\frac{1}{2}$ oz.

Calculating the Quantity of Yarn Required to Furnish 1 Yard of a Given Finished Cloth.

Since this calculation has already been discussed in the preceding chapter, there is no need to go over the same ground again.

Calculating the Correct Length to Warp a Known Weight of Yarn.

This is one of the most frequently recurring problems, and about the most important calculation that has to be made in respect of yarns. The question arises under the following circumstances:—

Example 1.—When the warp has to be of a certain length, and one is not quite sure whether the available length of yarn will be sufficient.

It will be readily understood that it is impracticable to make up any deficiency in the warp by means of another yarn, since this would lead to stripes in the warp. Where the deficiency is one-half, one-third, or one-fourth of the total warp ends, the situation may be saved by afterwards beaming the warps in a corresponding proportion, *viz.*, 1 to 1, 1 to 2, 1 to 3, or eventually 1 to 4 on one and the same beam, or on two beams when that number is present and weaving them together. Of

course the design to be woven must be suitable to the arrangements adopted. In any case a few fresh or different ends can be inserted near the selvages in order to make up the width without injury to the whole.

Supposing we have 56 lb. of a yarn running 8000 yds. to the lb. or a total length of 448,000 yds. The warp is to be set in a reed of 12½ four-end dents per inch, and the width is 72 ins. We therefere require 3600 warp ends. The utmost length of each end is found by dividing the number of ends into the total length of yarn available, *i.e.*, 448000 ÷ 3600 = 124·42. Consequently the warp ends must not be more than 124 yds. long, unless a lighter reed be taken or the width of the cloth reduced.

Assuming the length required is 134 yds., it might be considered feasible to increase the quantity of yarn by incorporating with it the necessary amount of another parcel. Let us see how this works out. The ratio between 124 and 134 is 37 : 40, and we should therefore be obliged to warp the yarns as follows :—

12	ends of the	old	yarn.
1	,,	new	,,
12	,,	old	,,
1	,,	new	,,
13	,,	old	,,
1	,,	new	,,
Together 40	ends.		

This proportion, however, cannot be employed, since any irregularities produced by the new yarn would appear all the more distinctly through being so far apart as an interval of 12 ends. The best mixtures are 1 : 1, 2 : 1, 3 : 1 according to the pattern, and if the pattern or the yarn allow as high as 4 : 1 may be taken. Beyond this limit, however, defective results will be obtained.

Example 2.—Assuming we have to cut a set of warps 75 yds. long for a cloth 70 ins. wide, to be set in a reed with 12½ six-end dents per inch, and we have available 30 lb. of face warp running 9250 yds. to the lb., and 28 lb. of back warp running 5000 yds. to the lb. Two face warps are to be set to

each back warp. Will the above yarn be sufficient, or how must the yarn be warped?

In the first place, a calculation may be made as in the previous example, to find the utmost length of warp ends the yarns will yield.

The reed has $12\frac{1}{2}$ six-end dents per inch, and of each 6 ends 4 must be of face warp and 2 of back warp. For the face warp we therefore require $12\frac{1}{2} \times 4 \times 70 = 3500$ ends, and for the back warp $12\frac{1}{2} \times 2 \times 70 = 1750$ ends.

The 30 lb. of face warp yarn will furnish $9250 \times 30 = 277500$ yds., and on dividing this by the number of ends required, *viz.*, 3500, we obtain $79\frac{1}{4}$ yds. as the length the yarn will cut.

The 28 lb. of back warp will yield $5000 \times 28 = 140000$ yds., which figure divided by the 1750 ends required gives 80 yds. as the length this back warp yarn will give. As, however, the face warp yarn will not furnish more than $79\frac{1}{4}$ yds., the back warp ends must not exceed that length, or there will be a shortage of face warp ends.

Example 3.—It is desired to weave a cloth for gents' suitings out of a single kind of yarn, No. 56/2, the width being 64 ins. between selvages and the reed containing $16\frac{1}{4}$ four-end dents per inch. The stock of yarn weighs 136 lb., and the weft count is to be 70 picks per inch. The problem is to find what length may be warped if the whole of the yarn is to be used, and the weft contraction in the loom amounts to 5 per cent.

The width being 64 ins. and the reed containing $16\frac{1}{4}$ four-end dents per inch, the number of warp ends required will be $16\frac{1}{4} \times 4 \times 64 = 4160$, and 4160 yds. of yarn will be needed for each yard of warp.

The number of picks is 70 per inch or 2520 per yard. Each pick will measure 64 + 2 ins. (selvages) = 66 ins., and therefore the 2520 picks will have a length of $(2520 \times 66) \div 36 = 4620$ yds. The weft contraction in the loom will be 5 per cent., the tension in weaving being less than that employed in reeling the yarn. Hence, these 4620 yds. will only represent $100 - 5 = 95$ per cent. of the weft material, which will therefore be

$$(4620 \times 100) \div 95 = 4683 \text{ yds.}$$

We therefore require for each yard of unfinished cloth :—

4160 yds. of yarn for the warp
4863 ,, ,, weft

a total of 9023 yds. of yarn.

Now the 136 lb. of stock yarn will run 15,680 yds. to the lb. (No. 56/2 being equal to No. 28 singles), so that the total length of yarn available will be $15680 \times 136 = 2132580$ yds.; and, since 9023 yds. of yarn are needed per yard of cloth, the length that may be warped is found by dividing the total length of the yarn by this latter figure, $2132580 \div 9023 = 236{\cdot}3$ yds.

Example 4.—Take the case where a check is to be woven from the following yarns :—

$20\frac{3}{4}$ lb. of black worsted yarn No. 64/2.
24 lb. of grey mixture worsted yarn No. 56/2.
$\frac{1}{2}$ lb. of blue-grey worsted yarn No. 60/2.

The width between selvages is 66 ins., and the reed contains $17\frac{1}{2}$ four-end dents per inch. The weft contraction is 5 per cent., the number of picks is 70 per inch, and the picks follow in the same order with regard to colour as the warp.

The warp is to be shorn as follows :—

4 ends of	mixed		
2 ,,	black	$\times 3 = 36$	ends
2 ,,	mixed		
4 ,,	black		
6 ,,	mixed	$\times 6 = 72$	,,
6 ,,	black		
4 ,,	mixed	4	,,
2 ,,	black	2	,,
2 ,,	mixed	2	,,
4 ,,	black	4	,,
4 ,,	mixed	4	,,
2 ,,	black	2	,,
2 ,,	mixed	2	,,
3 ,,	black	3	,,
1 ,,	blue-grey	1	,,

Together 132 ends to a repeat.

How long can the warps be cut?

For each repeat of the colour pattern we require 66 mixed, 65 black and 1 blue-grey end, and $4620 \div 132 = 35$ repeats go to the full width of 66 ins.

Since 66 mixed ends go to a repeat, the 35 repeats entail the use of 2310 of these mixed threads, and 2310 yds. of the same will be needed per yard of unfinished cloth.

The number of picks is 70 per inch or 2520 picks per yard, and, as already mentioned, there are 132 threads in the colour repeat, so that there will be $2520 \div 132 = 19$ repeats per yard. These repeats correspond to $66 \times 19 = 1254$ threads of the mixed yarn per yard of cloth.

Each pick has a length of 66 ins. plus 2 ins. for the selvages, or 68 ins. in all, and therefore the 1254 picks will take

$$1254 \times 68 = 2368\tfrac{1}{2} \text{ yds. of yarn.}$$

However, since the weft contracts 5 per cent., these $2368\frac{1}{2}$ yds. are only 95 per cent. of the total requirement, which will therefore be $(2368\frac{1}{2} \times 100) \div 95 = 2493$ yds.

Hence, for each yard of cloth there will be needed :—

2310 yds.	of the	mixed	yarn for the	warp
2493	,,	,,	,,	weft

Together 4803 yds. of mixed yarn.

The stock of this mixed yarn is 24 lb. running 15,680 yds. to the lb., No. 56/2 being equivalent to No. 28 singles, and the total available length of this yarn is $15680 \times 24 = 376320$ yds., so that the warp length this quantity will yield is

$$376380 \div 4803 = 78\tfrac{1}{4} \text{ yds.}$$

Of the black warp threads 65 are required for each repeat of the pattern, the 35 repeats therefore taking $35 \times 65 = 2275$ warp ends, or 2275 yds. per yard of cloth.

As stated above, there are 19 repeats per yard in the weft, or $65 \times 19 = 1235$ picks per yard of cloth. The length of each pick is 66 ins. plus 2 ins. for selvages or 68 ins. in all, therefore the 1235 picks will take $1235 \times 68 = 2333$ yds. On adding the allowance of 5 per cent. for weft contraction in the loom, we obtain $(2333 \times 100) \div 95 = 2455\frac{1}{2}$ yds.

For the black yarn we have therefore to take :—

	2275	yds. for the warp	
	$2455\frac{1}{2}$	,, ,, weft	
Together	$4730\frac{1}{2}$	yds. per yard of cloth.	

The stock of black yarn is $20\frac{3}{4}$ lb. running 17,920 yds. to the lb., the total length therefore being $17920 \times 20\frac{3}{4} = 371840$ yds. This divided by the $4730\frac{1}{2}$ yds. gives 78·6 yds.

Of the blue-grey threads, 1 end is needed for each repeat of the pattern, or 35 ends for the 35 warp repeats, *i.e.*, 35 yds. per yard of cloth.

There being also only 1 blue-grey pick for each repeat in the weft, the 19 repeats per yard will therefore mean 19 picks, each of 68 ins., or a total of $(19 \times 68) \div 36 = 36$ yds. Allowing for the 5 per cent. contraction in the loom, this length will therefore be increased to $(36 \times 100) \div 95 = 38$ yds.

We thus require :—

35 yds. for the warps
38 ,, ,, wefts

73 yds. of blue-grey yarn per yard of cloth.

The stock of this yarn is $\frac{1}{2}$ lb. No. 60/2 equivalent to No. 30 singles. This running 16,800 yds. to the lb. gives us 8400 yds. available. On dividing this figure by 73 we obtain 115 yds. as the length it will give.

The mixed yarn in stock is therefore sufficient to cut						$78\frac{1}{4}$	yds.
black	,,	,,	,,	,,	,,	78·6	,,
blue-grey	,,	,,	,,	,,	,,	115	,,

The warps, however, must not be cut longer than $78\frac{1}{4}$ yds., otherwise the stock of mixed yarn will be insufficient.

Example 5.—In connection with remnants of yarn and their utilisation in beaming warps, it has already been mentioned that the most favourable ratios are 1 : 1, 2 : 1 or 3 : 1, provided the colours and materials harmonise. The more, however, these limits are exceeded, the greater is the risk of forming stripes in the cloth. This danger is less imminent when striped or check patterns are in question, or weft effects are to be

produced on the face, the irregularities being concealed in the one case by the stripes or checks, and in the other by the weft.

Should the remnants of yarn be too small to allow them to be combined properly within the above limits, it is preferable to work them up into shorter pieces, there being always a difficulty in getting rid of defective goods. Unless the remnant is from an expensive yarn it had better be worked up as back warp, if there is any risk of producing irregularities; and, indeed, it is preferable to turn such yarn into shoddy rather than spoil good cloth with it.

There is less difficulty with remnants of weft yarn, since these can be used up in weaving pieces of corresponding length, and the warp remnants are always the source of the most trouble.

Suppose we have a remnant of $8\frac{1}{2}$ lb. of No. 42/2 yarn, and wish to work it in for weaving a piece 47 yds. long, the width of the goods being 66 ins. between selvages, and the reed containing $17\frac{1}{2}$ four-end dents per inch. The problem is, how to distribute the remnant among a parcel of new yarn of the same count, so as to prevent any irregularity in the cloth.

The reed having $17\frac{1}{2}$ four-end dents to the inch, the number of warp ends will be $17\frac{1}{2} \times 4 \times 66 = 4620$. Now, the contraction of the warp in the loom will vary according to the mode of weave employed, the thickness and setting of the weft, and the tension put on the warp threads themselves, from 5 to 8 per cent. and even more. Let us assume 7 per cent. to be the contraction in the present instance, and also allow for a shrinkage of another 5 per cent. in the finishing process, a total of 12 per cent. The 47 yds. of cloth to be produced will therefore represent only 88 per cent. of the total warp length required, which will thus be $(47 \times 100) \div 88 = 53{\cdot}4$ yds. To this must be added, say $0{\cdot}6$ yds. for thrums at the end of the piece, making the total length of the warp ends 54 yds.

The 4620 ends will take $4620 \times 54 = 249480$ yds. of yarn. The remnant is No. 42/2 or 11760 yds. to the lb., and therefore the amount of this yarn needed to weave the whole piece would be $249480 \div 11760 = 21\frac{1}{4}$ lb. The amount of the stock, however,

is only $8\frac{1}{2}$ lb., or in the proportion of 2 : 5 to the total required. We must therefore take 3 ends of the new yarn to every 2 of the old, and the whole parcel may be beamed as follows :—

2 ends of the new yarn.
1 end ,, old ,,
1 ,, ,, new ,,
1 ,, ,, old ,,
—
Total 5 ends per group.

This arrangement entails beaming the warp into a number of ends divisible by 5, *e.g.*, 10, 20, 30, 40, etc. It is, however, open to the disadvantage that if the beaming be done by hand and the warper should turn his hand the wrong way occasionally, the result would be that we should have on one side 4 ends of the new and on the other side 2 ends of the old yarn together, thus leading to irregularities in the weaving. On the other hand, if the following arrangement be employed such a result is rendered impossible :—

1 end of new yarn.
1 ,, old ,,
1 ,, new ,,
1 ,, old ,,
1 ,, new ,,
—
Together 5 ends per group.

Example 6.—How many ends will be needed to form the warp for a striped material 42 ins. wide in cotton, linen or half-woollen for curtains, napery or ladies' garments, the one class of stripes being 2 ins. wide, plain or taffeta weave, and set in a reed with 20 two-end dents per inch, whilst the other stripes are 1 inch each, in atlas or crape weave, and a 20 four-end dent reed ?

The width of the cloth is 42 ins. ; the first stripes are 2 ins. and the second 1 inch wide, or 3 ins. together ; hence the total number of stripe repeats in the width will be $42 \div 3 = 14$, that is to say, there will be 14 stripes of 2 ins. each and 14 one-inch stripes. The reed having 20 dents per inch, each two-

inch stripe will occupy 40 dents. Each dent will carry 2 ends, so that the 40 dents will take 80 ends, and the 14 stripes will require 14 × 80 = 1120 ends.

The one-inch stripes will occupy only 20 dents each, but as each dent holds 4 ends in this case, the 20 dents will take 80 ends and the 14 stripes will require 14 × 80 = 1120 ends. The total number of ends making up the full width of the fabric will, therefore, be 2240.

The method of distributing these stripes so as to ensure symmetry at both sides does not belong to the present section. (See Calculating Harness.)

SECTION II.

WORKING CALCULATIONS.

CHAPTER I.

REEDS, ETC.

THE calculations included under the heading of this section are as follows :—

1. Calculating the lease when the yarn is warped by hand.
2. The various calculations incidental to the reed.
3. Calculation of the number of picks required for a given cloth.
4. Cost of weaving.
5. Contraction of warp and weft in the loom.
6. Calculating the size of pulleys and speed of power looms.
7. Calculation of the number of picks inserted in a day's work of given length, and a given number or speed of looms.
8. Harness calculations for regular, irregular and reduced draft.
9. Calculation of Jacquard harness.
10. Calculating the comber board.
11. Calculating the number of empty healds in drafting and tying up the warp.
12. Calculating the tie-up plan.
13. Calculations in the finishing process.
14. Calculating the loss in weight sustained by woollens in finishing.
15. Calculating the weight of a fabric from a small cutting.

Calculating the Leasing of Hand-warped Yarn.

Supposing a yarn, all of one colour, is to be warped, the rake or raddle available having 5 teeth per 2 ins., and the fabric is to have a warp setting of 15 six-end dents per inch, the width being 66 ins. between selvages, what number of warp ends will have to be taken so as to avoid any gaps in the raddle and an undue number of ends in any one place, resulting in stripes?

With a reed having 15 six-end dents per inch, and a fabric 66 ins. wide, $15 \times 6 \times 66 = 5940$ ends will be needed; and as there are 5 teeth in the raddle every 2 ins., *i.e.*, 165 teeth in 66 ins., the number of ends to be leased between each pair of teeth will be $5940 \div 165 = 36$ ends.

The Various Calculations Incidental to the Reed.

The reed setting of any warp is dependent on a variety of factors, *e.g.*, the class of fabric, the price, the nature of the raw materials, the count of yarn, and especially on the kind of weave.

The calculations now given relate to:—

(*a*) The number of dents per inch for a given number of ends and width of cloth, with equal and unequal grouping.

(*b*) The number of warp ends for a given reed, width of cloth and grouping.

(*c*) The proper reed setting for given equal ratios of ends and picks.

(*d*) The proper reed setting when the warp and weft yarns are of unequal count.

(*e*) The proper reed setting to ensure symmetry in the count of warp and weft when the trials on the experimental loom have proved abortive.

(*f*) The proper reed setting for a given weave.

(*g*) The proper reed setting in the case of goods that turn out too light or too heavy.

Calculating the Number of Dents per Inch for a Given Number of Warp Ends and Width of Cloth with Equal and Unequal Groupings.

Example 1.—Assuming we have 7200 warp ends to set for a width of 70 ins. between selvages and wish to enter 8 ends to a dent, what reed should be taken?

There being 8 ends to a dent, the number of ends divided by this figure will give $7200 \div 8 = 900$ dents, which, divided by the number of inches, will give $900 \div 70 = 12\frac{3}{4}$ dents to the inch.

Example 2.—A warp of 4050 ends is to be set for 72 ins. cloth and the style of weave entails setting alternately 4 and 5 ends to a dent. What kind of reed will be required?

Since the number of ends to a dent is alternately 4 and 5, we have 9 ends to each repeat. Of these repeats we, therefore, have $4050 \div 9 = 450$ times 2 dents, *i.e.*, 900 dents. As these have to be distributed over a breadth of 72 ins., there will, therefore, be $900 \div 72 = 12\frac{3}{4}$ dents to the inch.

Calculating the Number of Warp Ends for a Given Reed and Width of Cloth with Equal and Unequal Groupings.

Example 1.—Let us take a 20 six-end dent for a $70\frac{1}{2}$ inch cloth and ascertain how many warp ends will be required. This is found by multiplying the reed on the number of ends to a dent and the product by the width of the cloth, $20 \times 6 \times 70\frac{1}{2} = 8460$ warp ends.

Example 2.—Given a reed containing $17\frac{1}{2}$ dents per inch, each dent to take alternately 5 and 6 ends. The cloth being 68 ins. wide between selvages, what number of warp ends will be needed?

The number of ends to a dent being alternately 5 and 6, we have in a $17\frac{1}{2}$ dent reed $17\frac{1}{2}$ five-end dents and $17\frac{1}{2}$ six-end dents in 2 ins., that is to say, a total of $87\frac{1}{2} + 105 = 192\frac{1}{2}$ ends in 2 ins., or 6545 ends in all.

Calculating the Proper Reed Setting for Given Equal Ratios of Yarn.

Example 1.—Take the case where a No. 16 yarn has been woven in a reed with 10 four-end dents per inch; the problem is to find what reed will be required for the same weave in No. $10\frac{1}{2}$ yarn. The answer is found by first taking the square roots of the yarn numbers.

The square root of 16 $= 4$.
,, ,, ,, $10\frac{1}{2} = 3\frac{1}{4}$.

Then since a No. 10 reed was used for the former, the reed required for the thicker yarn will be $(10 \times 3\frac{1}{4}) \div 4 = 8$ dents per inch.

Example 2.—Suppose that in weaving a certain pattern with No. 40/2 yarn we have employed a reed with $17\frac{1}{2}$ four-end dents per inch, what reed must be used for producing the same pattern with No. 64/2 yarn?

The No. 40/2 yarn is the same as No. 20 singles, and No. 64/2 is equal to No. 32 singles. Now the square root of 20 is 4·41, and the square root of 32 is 5·65; hence the desired reed will have $(17\frac{1}{2} \times 5{\cdot}65) \div 4{\cdot}41 = 8$ dents to the inch.

Example 3.—Two yarns are being used, one No. 64/2 the other No. 32/2, end for end regularly throughout the whole warp, and to produce a certain weave the low number yarn entails the use of a 20 four-end dent reed, the finer yarn a 14 four-end dent reed. What reed must be used for the two together?

The answer in this case is found by adding the two reed values together and dividing by 2; thus $(20 + 14) \div 2 = 17$ four-end dents per inch is the reed required.

Example 4.—In this case we have three kinds of warp yarn, one requiring the use of a 19 dent reed, the second a 14 dent reed, and the third a 9 dent reed, and the three kinds are used in equal proportion 1 : 1 : 1. What reed must be taken?

In this case the reed values must be added and the sum divided by 3, *i.e.* $(19 + 14 + 9) \div 3 = 14$ dents per inch is the reed required.

EXAMPLE 5.—In conclusion we will take the following case: A No. 16 cotton warp has been woven with a reed containing 18 three-end dents per inch to produce a particular weave. What reed will be required to produce the same effect with a No. 36 yarn?

The square roots of these figures are 4 and 6 respectively; therefore since a No. 18 reed was used for the coarser yarn, the higher number will require a reed containing $(18 \times 6) \div 4 = 27$ three-end dents per inch.

CALCULATING THE PROPER REED SETTING WHEN THE CONDITIONS OF WARP AND WEFT YARNS ARE UNEQUAL.

Owing to the keen cutting of prices, attempts are constantly made to effect all possible economy of material in the case of inferior quality goods, and of working expenses in the case of medium and good quality fabrics. A method largely adopted nowadays for goods wherein the warp plays the most important part on the face is to use a fine yarn for the warp, the weft being twice (or even 3 to 4 times) as thick as the warp. By this means four advantages are secured at once, namely:—

1. A considerable saving in the cost of weaving.
2. An important economy in the expense of spinning, low count yarns being cheaper to spin than the higher numbers.
3. The use of a thick weft means increased speed in weaving, and thus a larger output is obtained than with fine wefts which run away with more time per yard of cloth woven.
4. A lower quality of raw material may be used for the coarse weft than for the higher numbers, since the finer the yarn the better the raw material necessary.

EXAMPLE 1.—Suppose we have a No. 42/2 warp and desire to use with it a No. 14/2 weft. Suppose further the warp yarn corresponds to a reed with 28 four-end dents, and the weft to a reed with 22 four-end dents per inch, and that a simple weave is in question, equal amounts of both yarn being used.

In view of this latter condition, all that is necessary is to add the two reed values together and divide by 2, *e.g.* $(28 + 22) \div 2 = 25$ four-end dents is the count of reed desired. If

a six-end dent reed be in question, the number of dents will be 17, and in the case of an eight-end reed $12\frac{1}{2}$ dents per inch according to the count of the warp.

Calculating the Proper Setting of the Reed for Symmetrical Warp and Weft Count in the Event of the First Trials on the Experimental Loom having turned out a Failure.

It happens only too frequently in practice that in trying new weaves the reed first chosen does not immediately suit. Again, dozens of weaves are tried with one and the same warp, and the wide-awake designer and manufacturer allows the sample weaver to determine the number of picks per inch, the samples being then marked with a ticket stating the number of picks woven. By proceeding in this manner the choice of the most suitable reed becomes a matter of little difficulty and simple calculation.

Example 1.—Assuming that a sample has been produced by means of a reed containing $17\frac{1}{2}$ four-end dents per inch, and has taken 95 picks per inch, what reed must be employed in order to bring the warp and weft into equal proportion in the unfinished cloth?

With the $17\frac{1}{2}$ four-end dent reed the number of ends per inch is 70, so that we have $95 - 70 = 25$ picks too many. Since there are four ends to a dent, these 25 picks correspond to $25 \div 4 = 6\frac{1}{4}$ dents. Of these $6\frac{1}{4}$ dents one-half must be struck out for the reduced number of picks to be set per inch, leaving 3 dents for the warp. The latter must therefore be set in a reed containing $17\frac{1}{2} + 3 = 20\frac{1}{2}$ four-end dents to produce an equal number of ends and picks per square inch of fabric.

Example 2.—Take the case of a pattern produced with a reed containing 16 four-end dents per inch, but which despite close weaving cannot be made to hold more than 55 picks per inch; at the same time the fabric has to be well milled, and therefore requires to contain a larger number of picks, say 70 per inch. The problem is to ascertain the reed most suitable for the purpose.

As stated it is desired to insert 70 picks per inch. However, despite all endeavours, not more than 55 are actually taken up, a deficiency of 15 picks in each inch. The reed containing four ends to a dent, these 15 threads correspond to $15 \div 3\frac{3}{4}$ dents. This figure must be divided by 2, and the result deducted from the value of the existing reed, *i.e.*, $16 - 1\frac{7}{8} = 14\frac{1}{8}$, or in round figures a reed containing 14 four-end dents per inch must be taken in order to be able to insert 70 picks per inch.

Calculating the Proper Reed Setting for a Given Weave.

The weave or intersection of the threads is one of the main factors influencing the count of warp threads and choice of a reed. This question will now be briefly dealt with as follows :—

In respect of the crossing of the threads, the only ends that have to be taken into account in connection with the setting of the warp are such as form the average number passing from the top shed to the bottom, and *vice versâ* between each pair of picks.

It is therefore necessary to inform the reader of a simple method, in which by means of the square root he may calculate from the setting of a known weave with given yarns the setting to be given in the event of a change of the intersections.

This will be more clearly understood by a reference to the drawings, Figs. 1-6. In Fig. 1 the whole of the warp ends cross between each pair of picks, *i.e.*, one-half the warp ends pass from below upwards, and the other half from above downwards. Hence the number of intersections is equal to the number of ends. This method of crossing is expressed by the fraction $\frac{4}{4}$ or $\frac{2}{2}$, the numerator referring to the number of crossings, and the denominator to the number of ends in a repeat.

Turning to Fig. 2 it will be seen that, between the first and second picks, the second end passes from the lower shed into the upper, and the third end from the upper shed into the

lower. Hence, out of 3 ends we have 2 that change their position, *i.e.*, intersect. This weave is therefore represented by the fraction $\frac{2}{3}$.

Since between each two picks in Fig. 3, which is a four-end pattern, each two ends cross, the weave is classed as a $\frac{2}{4}$ pattern. In Fig. 4 there are 6 warp ends, and between each pair of picks two ends intersect, so that the weave is a $\frac{2}{6}$ pattern. Fig. 5 is different, inasmuch as here we have no longer to do with single ends, but with groups of pairs by which the crossings are effected. It will therefore be clear that it is by no means immaterial whether we have to do with single ends or with two, three or more warp ends in a group.

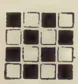

FIG. 1.

FIG. 2.

FIG. 3.

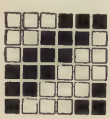

FIG. 4.

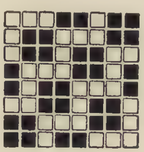

FIG. 5.

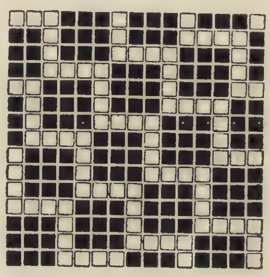

FIG. 6.

In the case of groups of two ends a deduction of $\frac{1}{4}$ can be made from the intersections (see Fig. 5); with groups of three ends a deduction of $\frac{1}{3}$ (see Fig. 6), and with groups of four a deduction of $\frac{1}{2}$ and so on.

In Fig. 5 we find that between each pair of picks there are 4 warp ends that change their position, and as there are 8 ends to a repeat, the weave may be classed as $\frac{4}{8}$; but, since a deduction of $\frac{1}{4}$ may be made only three changes come under consideration in estimating the intersection with a view to arriving at the count, and therefore the fraction becomes $\frac{3}{8}$ instead of $\frac{4}{8}$. If we examine Fig. 6 we find that the same is 15 ends broad, and that 6 ends change their position after each

pick, so that the weave would be $\frac{6}{15}$. But as the groups of 3 ends cross each other after every pick, the 6 crossings may be reduced by $\frac{1}{3}$, *i.e.*, by 2, and the fraction therefore becomes $\frac{4}{15}$.

The variety of crossings is innumerable in which single, two-, three- and four-end crossings occur alternately, and in such cases the average must naturally be taken.

Fig. 7 illustrates such a weave wherein single, double and multiple crossings are alternately produced. Thus, between the first and second picks there are two simple intersections, ends No. 3 and 7 changing their respective positions. Between the second and third picks 5 ends change positions, *viz.*, 1, 5, 6, 7 and 8, each of the last four crossing in pairs. Between the third and fourth picks 4 ends change position, *viz.*, Nos. 2, 3, 4 and 5, all of them crossing in pairs. Between the fourth and fifth picks 5 ends change positions, 4 of them crossing in pairs. Again, between the fifth and sixth picks there are two simple crossings, and between the sixth and seventh picks there are 5 changes 4 of them pairwise; between the seventh and eighth picks every alternate 4 ends cross in pairs, and between the eighth and first picks are 5 changes, 4 of them pairwise. We thus have :—

Between the 1 and 2 picks,	2 simple crossings . . .	$\frac{2}{8}$
,, ,, 2 ,, 3 ,,	5 crossings, 4 in pairs, so that, deducting $\frac{1}{4}$, there remains .	$\frac{4}{8}$
,, ,, 3 ,, 4 ,,	4 crossings, all in pairs, so that, deducting $\frac{1}{4}$, there remains .	$\frac{3}{8}$
,, ,, 4 ,, 5 ,,	5 crossings, 4 in pairs, so that, deducting $\frac{1}{4}$, there remains .	$\frac{4}{8}$
,, ,, 5 ,, 6 ,,	2 simple crossings . . .	$\frac{2}{8}$
,, ,, 6 ,, 7 ,,	5 crossings, 4 in pairs, less $\frac{1}{4}$, leaves	$\frac{4}{8}$
,, ,, 7 ,, 8 ,,	4 crossings, 4 in pairs, less $\frac{1}{4}$, leaves	$\frac{3}{8}$
,, ,, 8 ,, 1 ,,	5 crossings, 4 in pairs, less $\frac{1}{4}$, leaves	$\frac{4}{8}$

The sum of these figures is 26, and as the number of picks

is 8, 26 ÷ 8 = 3·25, *i.e.*, the fraction becomes $\frac{3{\cdot}25}{8}$, or a little less than in Fig. 3. Hence the warp ends for Fig. 7 may be set a little closer than those in Fig. 3.

To make a somewhat closer comparison we may take the crossings represented in Figs. 3, 4 and 7.

The crossings in Fig. 3 give the fraction $\frac{2}{4} = \frac{12}{24}$.
,, ,, Fig. 4 ,, ,, $\frac{2}{6} = \frac{8}{24}$.
,, ,, Fig. 7 ,, ,, $\frac{3{\cdot}25}{8} = \frac{9{\cdot}75}{24}$.

The requisite setting is, therefore, about midway between those for Figs. 3 and 4, and in fact a little nearer the latter than the former.

It has already been explained how the warp setting may be estimated in one count from that used for another by ex-

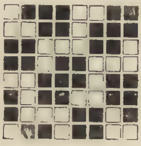

FIG. 7.

tracting the square roots of the two numbers and employing the results for comparison ; and this method may also be followed with regard to the intersection of the threads. Both numerators and denominators can be utilised as the basis in this calculation, the former when the denominators are all of equal value, and the latter when the numerators are equal. Where both are unequal, the fractions must first be reduced to a common denominator.

EXAMPLE 1.—Let it be assumed first that a certain warp used for a plain weave (Fig. 1) suits a reed with $17\frac{1}{2}$ two-end dents, or half that number of four-end dents per inch. What reed must be taken to weave the same yarn to a four-end cashmere twill (Fig. 3) the crossings in which are indicated by the fraction $\frac{2}{4}$?

The fraction representing the crossings in Fig. 1 is $\frac{2}{2}$ or $\frac{4}{4}$,

those in Fig. 3 agreeing with the fraction $\frac{2}{4}$. The denominators in this case being equal, the numerators may be used for determining the new reed. Now the square root of 2 is 1·41421 and that of 4 is 2, so that we have:—

1·41421 requiring a reed with $8\frac{3}{4}$ four-end dents, and hence the value for the new reed is $(8\frac{3}{4} \times 2) \div 1·41421 = 12·4$ dents, or $12\frac{1}{2}$ four-end dents per inch.

Example 2.—In this case a certain yarn suited a $16\frac{1}{4}$ three-end dent reed in weaving a three-end twill (Fig. 2), and it is desired to know how many ends of the same yarn will be needed in forming a six-end twill (Fig. 4).

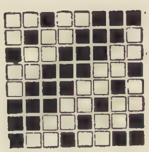

Fig. 8.

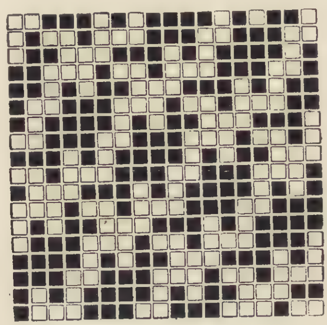

Fig. 9.

The crossings of the three-end twill (Fig. 2) are represented by the fraction $\frac{2}{3}$, and those of the six-end twill by $\frac{2}{6}$. The two numerators being of equal value in this case, the denominators are employed. The square root of 3 is 1·73205, and that of 6 is 2·449. Then since 1·73205 corresponds to a reed with $16\frac{1}{4}$ dents per inch $(16\frac{1}{4} \times 2·449) \div 1·73205 = 22·9$, or in round numbers 23 three-end dents, or $11\frac{1}{2}$ six-end dents, will be the count of reed required.

Example 3.—Let us now take into calculation the cases illustrated in Figs. 8 and 9. The crossings in the former may be represented by the fraction $\frac{4}{8}$ or $\frac{2}{4}$, whilst the latter averages $\frac{7}{18}$, *i.e.*, of each 18 ends 7 change between every 2 picks. As-

suming that a reed with $16\frac{1}{4}$ four-end dents per inch suits the former design, what reed will be needed for Fig. 9?

Since neither numerators nor denominators are of equal value, the two fractions $\frac{2}{4}$ and $\frac{7}{18}$ must be brought to a common denominator, namely $\frac{36}{72}$ and $\frac{28}{72}$, or $\frac{9}{18}$ and $\frac{7}{18}$. In this case the values 9 and 7 must be taken for comparison; and as their respective square roots are 3 and 2·646 we obtain $(16\frac{1}{4} \times 3) \div 2{\cdot}646 = 18{\cdot}4$, or $18\frac{1}{2}$ as the number of four-end dents in the required reed.

Calculating the Proper Reed Count in the Event of the Goods being too Light or too Heavy.

This calculation cannot be undertaken except in the case of goods that are to be only slightly if at all milled, since milling causes a shrinkage that varies with the count of the cloth.

Hence the employment of this calculation is restricted to cotton, linen, silk, half-woollen and worsted fabrics intended for dress materials. Two methods of calculation are available—one complex, the other easy; we will select the latter.

Example 1.—Suppose we have a fabric containing 45 ends and the same number of picks per inch and weighing $11\frac{1}{2}$ oz. per running yard. Suppose further that the purchaser desires to have the same cloth, but weighing $12\frac{1}{4}$ oz. per yard. What setting must be adopted to secure the increase in weight?

The answer is found by simple proportion, $(45 \times 12\frac{1}{4}) \div 11\frac{1}{2} =$ 48 ends and picks per inch of warp and weft.

Example 2.—Take the case of a worsted fabric with 50 ends and picks per inch of warp and weft and weighing $12\frac{1}{2}$ oz. per yard. This cloth is $1\frac{1}{4}$ oz. per yard too heavy. How must the count be altered to give the desired result?

Here again the matter is one of simple proportion, $(50 \times 11\frac{1}{4}) \div 12\frac{1}{2} = 45$ ends and picks per inch of warp and weft.

Calculating the Proper Weft Count for a Given Fabric.

The reasons for entering on this calculation may be of a varied character :—

(1) One may merely wish to know how many picks to insert for a given fabric ;

(2) In the event of a piece coming out too light or too heavy it may be desired to find the proper alteration to remedy this defect ; and

(3) The object may be simply to estimate the weft count in general.

Example 1.—A fabric has 8400 warp ends in a width of $67\frac{1}{4}$ ins. between selvages. How many picks should be inserted per inch to give the same count of weft as warp, the yarns being of equal count ?

The warp count per inch is found by dividing the width into the number of ends, *viz.*, $8400 \div 67\frac{1}{4} = 125$ ends per inch, and this will, therefore, be the number of picks required.

In this case the mutual contraction of the threads in weaving and finishing has been disregarded, and in fact is not considered except when exceedingly close calculation is desired.

Example 2.—A fabric has been woven with 60 picks of No. 32/2 face warp and 30 picks of No. 9 singles back weft per inch. The width is 66 ins., shrinking to 56 ins. when finished, but the cloth comes out 1 oz. per yard too heavy. How must the weft count be altered to remedy this defect, the warp count remaining unchanged ?

Each pick has a length of 66 ins. plus 2 ins. for selvages or 68 ins. in all ; and, as already stated, the customary allowance for weft contraction in the loom is 5 per cent., it being immaterial whether this allowance is reckoned on the weight or length of the weft yarn. We will adopt the latter basis in this case, and therefore have $(68 \times 100) \div 95 = 71\frac{1}{2}$ ins. as the total length of pick.

Now there are 2 face picks to each back pick, and therefore in each group of 3 picks there will be 143 ins. of face weft, and $71\frac{1}{2}$ ins. of back weft. The face weft is No. 32/2 yarn,

which runs 8960 yds. to the lb., and therefore 143 ins. will weigh 0·007 oz.

Of back weft we have only half the number of picks, but the yarn is double the weight per pick, and consequently the weight per group of 3 picks is $0·007 \times 2 = 0·014$ oz. The fabric is to be 1 oz. per yard lighter, so that the weaver must insert $1 \div 0·014 = 72$ groups (of 3 picks) less per yard, or 2 less per inch. The number of picks will therefore be, 56 of face weft and 28 of back weft per inch.

Example 3.—Take the case of a fabric that is too light by 1 oz. per yard, and the number of face and back picks is respectively 75 and 25 per inch. The face weft is No. 16 and the back weft No. $4\frac{1}{2}$ yarn, and the width of the cloth is 74 ins. in the loom, selvages included. How many extra picks per inch must be inserted to increase the weight by 1 oz. per yard?

Each pick measures 74 ins. to which must be added an allowance of 5 per cent. for contraction, making the length of the pick $77\frac{1}{2}$ ins. The ratio of face to back weft is 3 : 1, so that each group contains $3 + 1 = 4$ picks. Hence the face picks in a group measure $77\frac{1}{2} \times 3 = 232\frac{1}{2}$ ins. The yarn being No. 16, runs 8960 yds. to the lb., and therefore $232\frac{1}{2}$ ins. will weigh $(323\frac{1}{2} \times 16) \div (8960 \times 36) = 0·0115$ oz.

The back weft being No. $4\frac{1}{2}$ runs 2520 yds. to the lb., and hence $77\frac{1}{2}$ ins. will weigh $(77\frac{1}{2} \times 16) \div (2520 \times 36) = 0·0132$ oz.

Each group of 4 picks contains 3 face picks weighing 0·0115 oz.
,, ,, ,, 1 back pick ,, 0·0132 oz.

Together 0·0247 oz.

The increase in the number of groups will therefore be $1 \div 0·0247 = 40$ per yard of cloth. This makes 120 picks to be added to the face weft, already 2700 picks per yard, the total being therefore 2820, or 78 face picks per inch; whilst in the case of the back weft, the existing 900 picks per yard must be augmented by 40, a total of 940 or 26 picks per inch.

Example 4.—Given a No. 56/2 warp yarn with 9400 ends

in the full width of the cloth (68 ins.), the problem is to find the number of picks of No. 35/2 weft yarn to use up a quantity equal to that of the warp yarn.

The No. 56/2 warp is equivalent to No. 28 single, and the No. 35/2 weft to No. $17\frac{1}{2}$ single. The number of warp ends in 68 ins. is 9400 or 138 per inch. Now, if No. 28 yarn is set 138 threads per inch, No. $17\frac{1}{2}$ yarn must be set

$$138 \times 17\tfrac{1}{2} \div 28 = 89 \text{ picks per inch.}$$

Of course to be quite accurate, the different contraction of the warp and weft yarns should be taken into consideration, though the results are sufficiently close without. Moreover, a number of instances of the way to make this additional calculation have been already given.

Example 5.—Supposing we have a fabric with an equal number of face and back picks of No. 16 yarn, and suppose further that the cost of weaving is too high, or that the material used for the back weft is unsuitable for making into such a high number as 16's yarn. Consequently the necessity arises of altering the ratio of the face and back picks, either to 2 : 1, 3 : 1 or even 4 : 1, and this brings the problem, What yarn should be taken for the back picks?

When the back weft is in the ratio 1 : 1, the yarn used is No. 16. In order to find the count suitable for a 2 : 1 ratio, the original yarn number must be divided by 2, *i.e.*, 16 ÷ 2 = No. 8 yarn will be the count required.

If the ratio is to be 3 : 1, the original number will have to be divided by 3, *i.e.*, 16 ÷ 3 = No. $5\frac{1}{4}$-$5\frac{1}{2}$ yarn, and if a ratio of 4 : 1 be chosen the required yarn will be 16 ÷ 4 = No. 4.

Calculating the Picks for Broché Effects on Fancy Fabrics.

The fabric is, say, a vest material on which broché effects are to be produced, the ground picks number 80 per inch, and furthermore 2, 3 or 4 broché picks are to be inserted at intervals. The total length occupied by a repeat of the pattern is 14 ins. made up as follows :—

2×2	ins.	together	4	ins.	without	broché	picks.
$2 \times 1 \cdot 6$	,,	,,	$3 \cdot 2$	,,	with 2	,,	,,
$2 \times 1 \cdot 6$	,,	,,	$3 \cdot 2$	,,	with 3	,,	,,
$2 \times 1 \cdot 8$	,,	,,	$3 \cdot 6$	,,	with 4	,,	,,

How many picks will be needed for a piece measuring $27\frac{1}{2}$ yds?

Since each repeat occupies a length of 14 ins., and there are 80 picks of ground weft per inch, the number of ground picks in a repeat will be $80 \times 14 = 1120$.

In a single repeat we have to insert 2 broché picks to each ground pick over a length of $2 \times 1 \cdot 6$ ins. $= 3 \cdot 2$ ins., and since there are 80 ground picks per inch, the number of broché picks in this length will be $3 \cdot 2 \times 80 \times 2 = 512$. In the second length of $2 \times 1 \cdot 6$ ins. $= 3 \cdot 2$ ins. there are to be 3 broché picks to each ground pick, or $3 \cdot 2 \times 80 \times 3 = 768$ in all; and in the third length ($2 \times 1 \cdot 8$ ins.) there are 4 broché picks per ground pick, or $3 \cdot 6 \times 80 \times 4 = 1152$ in all. These together make:—

1120	ground picks.						
512	broché	picks	for the part	with	2 : 1	broché	picks
768	,,	,,	,,		3	,,	,,
1152	,,	,,	,,		4	,,	,,

Total 3552 picks per repeat.

The piece is to be $27\frac{1}{2}$ yds. long; therefore, since each repeat occupies a length of 14 ins., the total number of repeats in the length will be $27\frac{1}{2} \times 36 \div 14 = 70$ repeats, and since there are 3552 picks to a repeat the total number of picks in the $27\frac{1}{2}$ yds. will be $3552 \times 70 = 248640$. From these data the total number of broché picks can be easily deduced.

SECTION II. (*Continued*).

CHAPTER II.

WEAVING CALCULATIONS.

Calculating the Cost of Weaving.

The earliest method of paying the weaver for his work was by daily wages, but this was superseded by payment according to the length woven and the quality of the work. These methods, however, were not satisfactory. When payment by the day was in vogue the bad or slow workman received just as much as his skilled and accurate colleague, and even payment by the piece was not much more satisfactory, since the same rate was generally paid for inferior and light goods as for those of better quality and heavier weight. In all these cases a premium was as it were placed on bad workmanship.

Subsequently the system of payment by weight was adopted, the weaver receiving his weft yarn in weighed quantity, and being paid on the weight woven. This was "out of the frying pan into the fire". The honest weaver inserted the picks properly and returned the excess of yarn, this latter being then deducted from the price agreed upon. On the other hand, the dishonest workman concealed a portion of the yarn supplied him, threw it way, buried it in the ground, etc., and sometimes even dropped it into the yarn boxes of his fellow workmen. In this latter event a double injury was inflicted on the latter, namely, loss of pay and the formation of weft stripes in the piece.

Undoubtedly the best method of payment is that introduced at Verviers in the "sixties," namely, on the basis of the number of picks inserted, since this ensures the weaver being paid for what he has actually done; and if he has failed to insert the necessary number of picks he therefore receives a smaller sum in payment.

On the other hand it is not altogether just for the manufacturer to decline, as some do, to pay for any picks inserted in excess of the stipulated number, though, of course, there must be a reasonable limit to such excess, seeing that the manufacturer is not himself paid for any excess of weight above the standard to which the goods are sold.

The counting of the picks is effected in two ways :—

1. The picks are counted for a length of 4-8 ins. at several different places in the length of the piece, and the mean of the resulting figures is taken as the average. In this case the counting should not be performed too near the ends of the piece, since there the warp tension is not at its proper dimensions, and, therefore, the number of picks will not always be a fair criterion of the whole. Where counting is difficult, it is often the practice to insert a coloured counting thread. In the case of light goods, the weft count can be easily ascertained when the piece is spread on the table. For reckoning the scale of payment the weft should not be counted while the goods are in the loom, the tension to which the cloth is exposed causing an apparent diminution in the weft setting.

In some cases the persons appointed to do the counting perform their task when the goods are in the tenting frame, and then search out the most open spaces ; the most straightforward method, however, is to count, by lengths of 8 ins. each, when the goods are spread out on the table.

2. The second method of ascertaining the weft count is by means of the mechanical weft counter. Of these there are two kinds—those recording the number of picks on a dial plate, and those inserting a coloured counting thread and omitting connection with the weft at intervals of 500-1000 picks, the number of repetitions being marked down in chalk.

Rates Paid for Weaving.

I. *Tying on.*

Per	1000	picks of	white and single-colour goods		6d.
,,	1000	,,	multi-coloured goods		$7\frac{1}{4}$d.
,,	1000	,,	,,	,, and 2 warp beams	8d.

II. *Mounting the Harness.*

(*a*)	Up to 16 shafts	1s. 0d.
(*b*)	„ 24 „	1s. 6d.
(*c*)	Over 24 „	2s. 0d.

III. *Weaving per* 1000 *Picks in Single-acting Looms.*

1. For 2, 3, 4, 5 and 6 shaft goods, with undyed or single-coloured warp, not exceeding 4000 ends . . . . $1\frac{1}{4}$d.
2. The same class of goods with multi-coloured warp . . . . $1\frac{5}{16}$d.
3. For satins with white or single-colour warps of high setting . . . . . . $1\frac{3}{8}$d.
4. For satins with multi-coloured warps . . $1\frac{7}{16}$d.
5. For white or single-coloured 7-16 shaft goods, up to 6500 warp ends and 100 or more picks per inch . . . . . . $1\frac{7}{16}$d.
6. For white or single-coloured 17-24 shaft goods, up to 6500 warp ends and 100 or more picks per inch . . . . . . $1\frac{1}{2}$d.
7. For white or single-coloured 25-32 shaft goods, up to 6500 warp ends and 100 or more picks per inch . . . . . . $1\frac{9}{16}$d.
8. For white or single-coloured goods over 32 shafts, up to 6500 warp ends and 100 or more picks per inch . . . . . $1\frac{5}{8}$d.
9. For white or single-coloured goods, with 6500 ends and 400-250 picks per inch . . $\frac{1}{16}$d. extra.
10. For white or single-coloured goods, with 6500 ends and 250-150 picks per inch . . $\frac{4}{16}$d. „
11. For white or single-coloured goods, with 6500 ends and less than 150 picks per inch . $\frac{1}{16}$d. „
12. For white or single-coloured goods, with 6500-8500 ends . . . . $\frac{1}{16}$d. „
13. For white or single-coloured goods, with 8500-10,500 ends . . . . . . $\frac{1}{16}$d. „

14. For white or single-coloured goods, with more than 10,500 ends . . . . . . $\frac{1}{16}$d. extra.
15. With worsted weft, No. 8 and higher . . $\frac{1}{8}$d. ,,
16. ,, ,, Nos. 5-8 . . . $\frac{1}{8}$d. ,,
17. ,, ,, below No. 5 . . . $\frac{1}{8}$d. ,,
18. With worsted back warps . . . . $\frac{1}{8}$d. ,,
19. For single-piece warps, tying on and weaving 5 per cent. ,,
20. For fabrics with large patterns, difficult drafts and long cards, *i.e.*, over 100 . . . $\frac{1}{16}$d. ,,
21. For each additional shuttle over 3 . . . $\frac{1}{8}$d. ,,
22. ,, ,, warp beam . . . $\frac{3}{16}$d. ,,
23. For every additional colour . . . . $\frac{1}{8}$d. ,,
24. For back weft up to No. $6\frac{1}{2}$ . . . . $\frac{1}{8}$d. ,,
25. ,, ,, below No. $6\frac{1}{2}$ . . . $\frac{1}{8}$d. ,,

The foregoing are the prices paid to the weavers. In estimating the cost of production, they must be augmented by $66\frac{2}{3}$ per cent. on account of salaries (manager, designer, foremen), freight, power, rent, renewals and repairs, wear and tear of looms, etc., etc. In the case of double-acting looms the prices vary by 25-33 per cent. or even more.

Calculating the Contraction of Warp and Weft in the Loom.

In the foregoing calculations with regard to warps and wefts, certain definite percentages have been allowed for contraction in the loom. This contraction, however, is by no means an invariable quantity, and indeed cannot possibly be so, in view of the numerous factors concerned.

In the case of warp contraction the following factors enter into consideration :—

(*a*) The nature of the yarn.
(*b*) The thickness or count of yarn.
(*c*) The tension of the yarn.
(*d*) The intersection of the threads (class of weave).
(*e*) The number of picks inserted per inch of weft.

Influence of the Nature of the Warp on the Contraction in the Loom.

The contraction of the warp in the loom varies in accordance with the character of the yarn, whether elastic, stiff or hard. Let us examine Figs. 10 and 11, in which K indicates the warp and S the weft yarn.

In Fig. 10 the warp appears to be only very slightly bent. This is the case when the warp material is hard and inelastic, or when the warp tension is high, or finally when the warp has been heavily sized while the weft is more or less soft, elastic or moist. In such instances the weft will give way more readily than the warp; and it may, therefore, be said

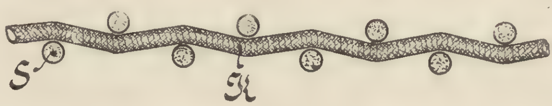

Fig. 10.

Fig. 11.

that hard warps contract very little when woven along with soft and elastic wefts and furnish a greater length of fabric, whereas soft warps contract more in presence of hard and stiff wefts, and, therefore, yield a shorter length of fabric.

Fig. 11 represents the antithesis of Fig. 10, the warp in this case suffering greater deflection, and, therefore, more contraction.

Influence of the Yarn Number on Warp Contraction.

If the warp and weft yarn be of equal thickness, the contraction will be nearly the same in each case, varying in accordance with the number of the intersections. This is illustrated in Fig. 12. The yarn in the upper half of this figure is thicker

than that in the lower, but the intersections are less numerous. Consequently the individual curves are greater, though this is more or less compensated by the larger number of crossings in the lower part of the figure.

The case is different when we have to deal with yarns of unequal thickness (count). Thick warps usually suffer little contraction in presence of fine weft, and fine warps contract a good deal when woven along with thick weft. In the former event the pieces attain a greater length for the same length of warp ends than in the latter.

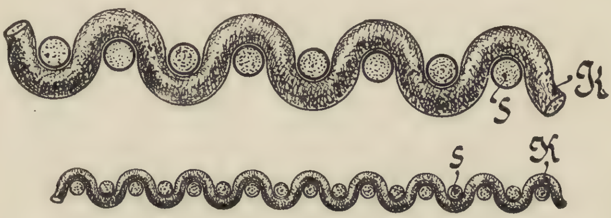

Fig. 12.

Effect of Warp Tension on Contraction.

It will be easily understood that a warp under high tension cannot contract to the same extent as one that is less tightly stretched, and consequently the more will the weft yarn be deflected in passing from the face of the fabric to the back and *vice versâ.*

Influence of the Class of Weave on Warp Contraction.

With regard to the method of weaving, a distinction may be drawn between three kinds of fabric :—

(*a*) Simple cloth.
(*b*) Cloth with two or more layers of weft threads.
(*c*) Double fabrics.

So far as simple fabrics are concerned it is clear that the greater the number of intersections the more will the warp contract in weaving, the greatest contraction occurring in the case of plain or taffeta weave.

5

Where the fabric has a back weft, the contraction is influenced by the frequency with which this weft engages with the warp, and also by the thickness of the back weft itself. The greater the number of bindings of the back weft the more extensive the warp contraction.

Consequently, the goods will come out shorter in the weave illustrated in Fig. 13, where the back weft *u*, is bound after every fourth face pick *o*, than in that shown in Fig. 14 where the intersection with the back weft occurs only after every eighth face pick.

Similarly, a fabric with thick back weft will weave to shorter length than one with a finer back weft, and moreover

Fig. 13.

Fig. 14.

the warp contraction increases in proportion to the number of weft layers in the fabric. When double fabrics are in question, where each warp has its own special weft, the contraction is the same as in simple fabrics, except that the binding together of the face and back fabrics also comes under consideration.

If the face weft be used to bind the back warp, the effect on the warp contraction is usually insignificant, the face weft being generally of fine yarn. The case is, however, different when the converse plan is adopted, the influence of the back weft then causing greater contraction ; on the other hand, when the binding is alternately with the face and back warps it has little influence on the contraction.

Influence of Weft Count on Warp Contraction.

Little need be said on this score, it being evident that the larger the number of picks inserted per inch the greater the number of intersections or bindings to which the warp is exposed, and therefore the more extensive the contraction.

The same applies to the relative proportion of back to face picks, the warp contracting more when the ratio is 1 : 1 than when one back pick is used to every second or third face pick.

Consequently, it is evident that the warp contraction cannot be accurately calculated or predicted with mathematical precision, but can only be ascertained after the fabric has been woven and measured. This measuring should not be performed immediately the goods leave the loom, but postponed for several hours to allow the fabric to recover from the tension to which it was subjected during weaving.

Weft Contraction in the Loom.

The contraction of the weft in weaving results from a different cause to that producing warp contraction. The latter is due to the intersection of the threads, whereas this has nothing to do with the contraction of the weft; in fact, the greater the number of intersections the wider will the goods come out. A piece of cloth in plain weave will come out wider than that containing the same number of ends in twill or atlas weave. In order to understand this, it is necessary to picture to oneself the weft thread as it lies in the shed; in being beaten up by the lathe it is driven in between the warp ends uniformly throughout the entire width of the cloth, so that any subsequent contraction is out of the question. On the contrary, a slight extension varying with the hardness and thickness of the warp yarn is sustained by the weft between each adjacent couple of warp ends.

The sole cause of the weft contraction is the fact that the weft yarn unwinds from the shuttle at a lower tension than that employed by the spinner in reeling for the purpose of determining the yarn number. Hence the greater the rebound

of the shuttle on entering the shuttle boxes, the looser will the weft yarn lie in the shed and the greater the contraction.

In this case, also, no previous calculation can be made, and it is customary to estimate the contraction at 5 to 6 per cent., this being about the average figure.

Size and Speed of Pulleys in Power Looms.

The weaver sometimes has to decide what size of shafting pulley and what number of revolutions per minute must be selected in order that the power loom may insert a given number of picks in unit time.

In making this calculation it is necessary to distinguish between two classes of loom: those wherein the number of picks is only $\frac{1}{3}$ the number of revolutions made by the loom pulley, and looms in which one pick is inserted for each turn of the pulley. The first five examples given below apply to the former class, the remainder to the latter.

Example 1.—A power loom has to be mounted so as to insert 110 picks per minute. Now, in the majority of looms for woollen goods there are two dimensions to be considered in the driving wheels. Then assuming the large cone wheel has 68 teeth, the small one 23, the loom pulley a diameter of 18 ins., and the shafting runs at 112 revolutions a minute, the size of shafting pulley to furnish the desired result has to be ascertained.

The rule on which this calculation is based is as follows: The diameter of the shafting pulley is equal to the product of the diameter of the loom pulley, and the desired number of picks multiplied by the number of teeth in the large cone wheel, the whole being divided by the product of the shafting speed and the number of teeth on the small cone wheel. If the diameter of the shafting pulley be expressed by T, we have the equation

$$T = \frac{18 \times 110 \times 68}{112 \times 23} = 52\tfrac{1}{4} \text{ ins.}$$

Example 2.—The large cone wheel of a loom has 70 teeth,

the small wheel 22 teeth, the diameter of the driving pulley is $16\frac{3}{4}$ ins., and the shafting makes 90 turns a minute. What size shafting pulley must be taken to give a loom speed of 75 picks a minute?

$$T = \frac{16\frac{3}{4} \times 75 \times 70}{90 \times 22} = 44\tfrac{1}{2} \text{ ins.}$$

EXAMPLE 3.—Since in practice the ease or difficulty with which the warp acts varies according to the class of weave, and this circumstance also has to be taken into account in fixing the speed of the loom, let it be assumed that, under the conditions already laid down in the preceding example, the number of picks per minute is to be reduced to 65. The problem then before us is to ascertain the number of teeth in the small change wheel that will give this result.

For 75 picks per minute the small wheel has 22 teeth

,, 1 pick ,, ,, ,, $\frac{22}{75}$,,

∴ ,, 65 picks ,, ,, ,, must have

$$\frac{22 \times 65}{75} = 19 \text{ teeth.}$$

Conversely with exceptionally good warps and an easy weave, the number of picks per minute may be increased. Assume in

EXAMPLE 4, that, under the same conditions as in No. 2, the weaver desires to insert 90 picks per minute, what size (number of teeth) of change wheel must be selected to effect the desired alteration?

For 75 picks per minute the small wheel has 22 teeth

,, 1 pick ,, ,, ,, $\frac{22}{75}$,,

∴ ,, 90 picks ,, ,, ,, must have

$$\frac{22 \times 90}{75} = 26 \text{ teeth.}$$

Whereas in the preceding examples the number of picks per minute is assumed to be known, the manufacturer or weaver is sometimes confronted by the problem laid down in

EXAMPLE 5.—How many picks per minute can be inserte

under a given set of circumstances? Let us take the following data: Speed of shafting 110 revolutions, diameter of shafting pulley 48 ins., number of teeth in large change wheel 96, in the small one 32, and diameter of loom pulley 18 ins.; then

The number of picks being expressed by S, the solution is based on the rule that S is equal to the product of the shafting speed and number of teeth in the small wheel multiplied by the diameter of the shafting pulley, the whole being divided by the product of the diameter of the loom pulley and the number of teeth in the large cone wheel, thus:—

$$S = \frac{110 \times 32 \times 48}{18 \times 96} = 98 \text{ picks per minute.}$$

Example 6.—Take the case of a quick-running loom inserting one pick at each revolution and desired to make 140 turns per minute. The shafting makes 100 turns a minute, and the loom driving pulley is 18 ins.; what must be the diameter of the shafting pulley?

This calculation is simple in the extreme. The desired number of picks per minute is multiplied by the diameter of the loom pulley, and the product is divided by the number of turns made by the shafting, *i.e.* $(140 \times 18) \div 100 = 25\frac{1}{4}$ ins. diameter of shafting pulley.

Example 7.—Given a shafting pulley 34 ins. in diameter, a loom pulley $20\frac{3}{4}$ ins. in diameter, and a loom speed of 180 picks per minute, to find the number of revolutions of the shafting.

The product of the number of picks and the diameter of the loom pulley is divided by the diameter of the shafting pulley:—

$$\frac{180 \times 20\frac{3}{4}}{34} = 110 \text{ turns per minute.}$$

Calculating the Number of Picks Inserted per Diem from a Given Number of Working Hours, Machines and Pulley Speed.

Example 1.—Assuming the loom to insert 60 picks per minute and the working day to be of 10 hours duration; further, allowing a loss of 30 per cent. for time consumed in

refilling shuttles, piecing broken ends and other contingencies; how many picks will the loom insert during 6 working days?

The allowance for contingencies is given as 30 per cent., but with bad warps and unskilled loom minders this may have to be increased to 40 per cent. and over; on the other hand, with very good warps it may be reduced to 18-25 per cent.

Ten hours per working day give $10 \times 60 = 600$ minutes, and since the loom inserts 60 picks per minute, we have a total of $600 \times 60 = 36000$ picks per diem. Allowing 30 per cent. for loss of time through contingencies, we have 70 per cent. as the useful effect of the loom; hence the net number of picks inserted per day will be $\frac{36000 \times 70}{100} = 25200$, and per week of 6 full days $25200 \times 6 = 151200$ picks.

Example 2.—If a loom make 85 picks per minute when in full swing, and the net effect be taken as 65 per cent., how many picks will be inserted in a working day of 10 hours?

Ten hours give us $10 \times 60 = 600$ minutes, which, at 85 picks per minute, furnish $600 \times 85 = 51000$ picks. Allowing the net useful effect to be 65 per cent., we have $\frac{51000 \times 65}{100} = 33150$ picks per day, or $33150 \times 6 = 198900$ picks per week of 6 working days.

Example 3.—We will now take the case of a loom running at high speed, *e.g.*, 125 picks per minute. Now the greater the speed the larger the number of refills and piecings, and, therefore, the lower the percentage of useful effect. Taking this, however, at 60 per cent., how many picks will such a loom insert in a week?

At a speed of 125 per minute, the loom will insert $125 \times 60 \times 10 = 75000$ picks per 10 hours' day. The net effect being 60 per cent.; however, this figure will be reduced to $\frac{75000 \times 60}{100} = 45000$ picks per day, or $45000 \times 6 = 270000$ picks per week.

SECTION II. (*Continued*).

CHAPTER III.

HARNESS CALCULATIONS.

Calculating a Harness for Regular, Irregular and Reduced Draft.

The drafting of a harness implies the insertion of the warp ends in the healds. If a similar warp has already been drafted in the harness there will usually be a short length of warp ends, or thrums, left behind in the harness, and in this case all that is necessary is to attach the ends of the new warps to these thrums. On the other hand, when a fresh harness is

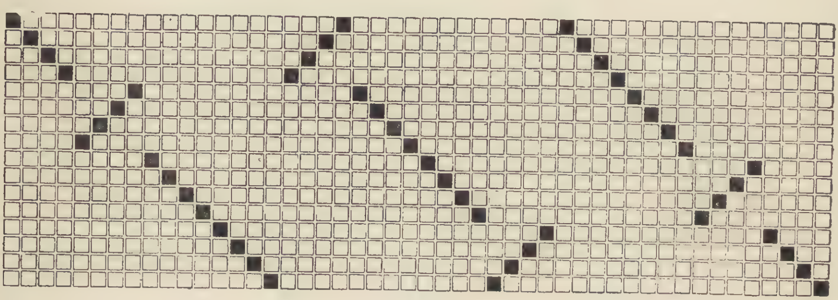

Fig. 15.

taken, or the new warp is to be drafted in a different manner, the harness will require to be redrafted. A distinction is drawn between three kinds of draftings: (*a*) regular, (*b*) irregular, and (*c*) reduced drafts.

Calculating Regular Draft.

Example 1.—Taking the case of a warp of 8262 ends to be woven to a width of 68 ins., with 18 shafts and regular draft,

how many healds will be needed to each shaft and how many per inch?

The last part of the problem, however, is important only when a fixed harness is in question.

Since the 8262 ends are to be drafted in 18 shafts, there will be $8262 \div 18 = 459$ healds, and as these are spread over

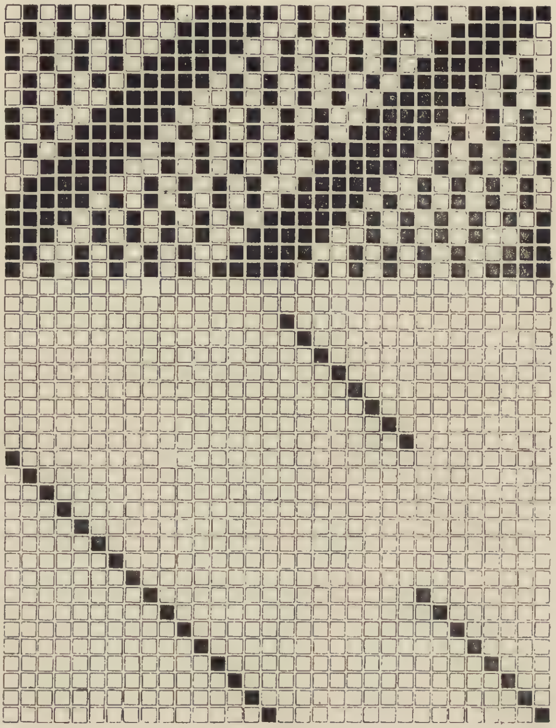

FIG. 16.

a width of 68 ins., there will be $459 \div 68 = 6\frac{3}{4}$ healds per inch. Where a fixed harness is in question and the number of healds exceeds the figure given, the remainder will have to be omitted in drafting, care being taken to ensure that the number of empty healds is uniformly distributed over the entire width of the cloth, and thus prevent irregular accumulations in parts.

Calculating Irregular Draft.

Strictly speaking, irregular draft is not invariably reduced draft. The term irregular is applied to a draft when the serial order is not maintained uniformly throughout, three examples of this condition of things being illustrated in Figs. 15-16A.

In Fig. 15 it will be seen, for instance, there is an alternated drafting of 8 ends to the left and 4 to the right, whereby stripes are formed in twills or diagonals. This could not very well be termed a reduced draft.

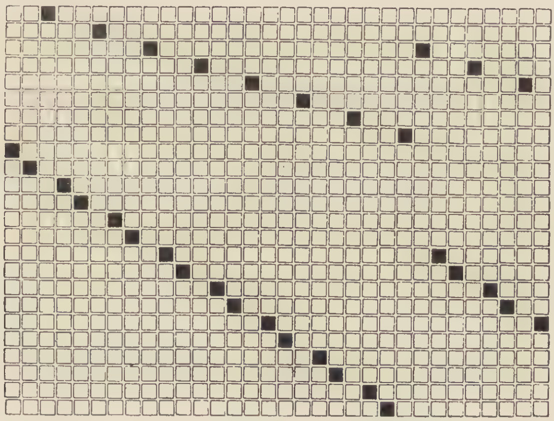

Fig. 16A.

Figs. 16 and 16A represent drafting of a somewhat different type. If the upper sharply intersecting weave were set somewhat close the warps could not easily form a clean shed, but if 32 shafts were available the work could be done. Assuming, however, that no loom with such a number of shafts is at hand, then another means must be sought; for instance, the number of shafts may be increased by one-half and the numerous warp ends distributed over this larger number.

The designing of textile fabrics is beyond the scope of the

present work, the task we have now in hand being merely to distinguish irregular draft from reduced draft.

In this instance three courses are open, two of these possibilities being represented in Figs. 16 and 16A. Moreover,

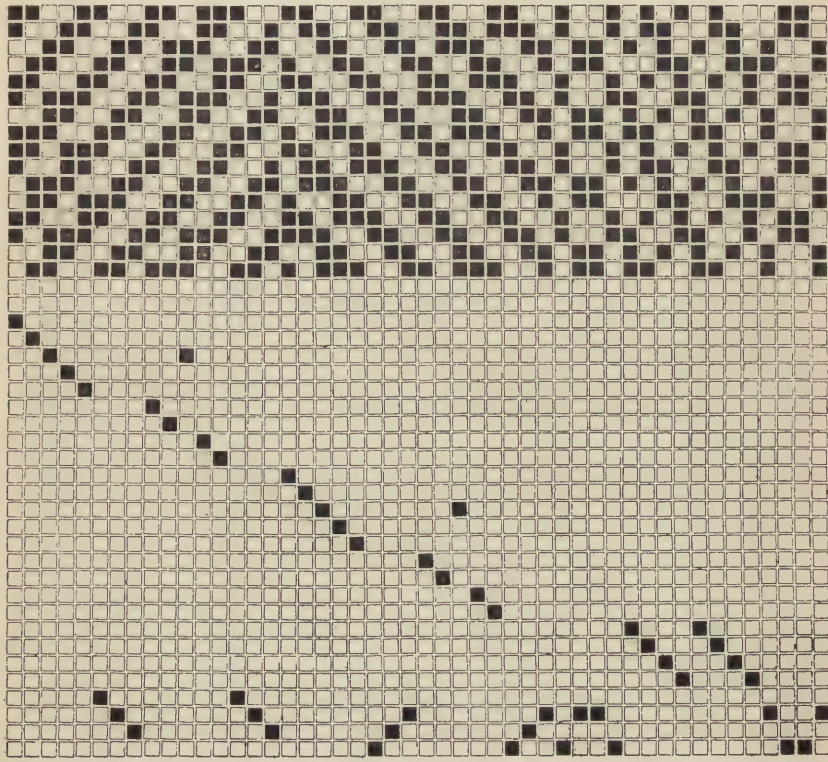

FIG. 17.

the weave might be worked with 16 shafts, the whole being drafted according to the Atlas type of weave.

As regards the number of healds per shaft in all three cases, they may be evenly distributed in the case of Fig. 15, but in the upper draft illustrated in Fig. 16 twice as many healds

would be allotted to each of the 8 front shafts as to the following 16 shafts; and for the lower draft and that shown in Fig. 16A particulars will be given in the following paragraphs.

Calculating Reduced Draft.

For this purpose we will make use of Fig. 17. Here we are supposed to have a reed with 15 four-end dents per inch, and a cloth 64 ins. wide, and the problem is, how many healds must be allocated to each shaft?

Each repeat of the pattern occupies 48 ends, and in the full width of the cloth there are $15 \times 4 \times 64 = 3840$ ends. The number of repeats in the width is found by dividing the number of ends by the number in each repeat $3840 \div 48 = 80$ repeats. In our reduced draft we have in the—

1st	or front shaft,	per repeat,	6 ends,	or in	80 repeats,	$80 \times 6 = 480$	ends.
2nd	,,	,,	4	,,	,,	$80 \times 4 = 320$	,,
3rd	,,	,,	8	,,	,,	$80 \times 8 = 640$	,,
4th	,,	,,	2	,,	,,	$80 \times 2 = 160$	,,
5th	,,	,,	2	,,	,,	$80 \times 2 = 160$	,,
6th	,,	,,	2	,,	,,	$80 \times 2 = 160$	,,
7th	,,	,,	2	,,	,,	$80 \times 2 = 160$	,,
8th	,,	,,	2	,,	,,	$80 \times 2 = 160$	,,
9th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
10th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
11th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
12th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
13th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
14th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
15th	,,	,,	2	,,	,,	$80 \times 2 = 160$	,,
16th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
17th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
18th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
19th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
20th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
21st	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
22nd	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
23rd	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
24th	,,	,,	2	,,	,,	$80 \times 2 = 160$	,,
25th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
26th	,,	,,	1	,,	,,	$80 \times 1 = 80$	,,
						Total 3840	ends.

On shaft	1	we therefore have			480	healds.
,,	2	,,	,,		320	,,
,,	3	,,	,,		640	,,
,,	4-8	,,	,,	each	160	,,
,,	9-14	,,	,,	each	80	,,
,,	15	,,	,,		160	,,
,,	16-23	,,	,,	each	80	,,
,,	24	,,	,,		160	,,
,,	25-26	,,	,,	each	80	,,

Calculating the Jacquard Harness.

The dimensions of the Jacquard harness mainly depend on the number of warp ends to be used and the form of pattern to be produced. The width of a figured fabric does not always entail the use of a harness of equal size, a great deal depending on the form or composition of the pattern.

Many of the necessary calculations for this purpose are of such a simple character that they may be left to the reader, and we will confine ourselves to the following:—

(*a*) Calculating regular draft harness,
(*b*) ,, central tie harness,
(*c*) ,, harness for bordered fabrics,
(*d*) ,, ,, striped goods,
(*e*) ,, ,, multiple draft.

Calculating Regular or Straight-draft Harness.

There are two sub-varieties of this type, single cord and multiple cord harness.

So far as the former of these is concerned, the term is applied to harness in which only a single cord is suspended from each hook, so that the dimensions of the machine must correspond exactly with the width of the goods to be woven. Thus, if a figured fabric of 1200 warp ends is in question, and each end performs its task independently, the machine must have 1200 hooks. This arrangement is adopted for the production of panneaux, imitation Gobelins, landscapes, portraits and the like. This harness is generally known as "single" harness.

An instance of this class is afforded by Fig. 18. At the top is seen the Jacquard machine with two rows of 12 hooks each. Lower down is the comber board connected with the rows of hooks, whilst lower still on the left are 12 cords with

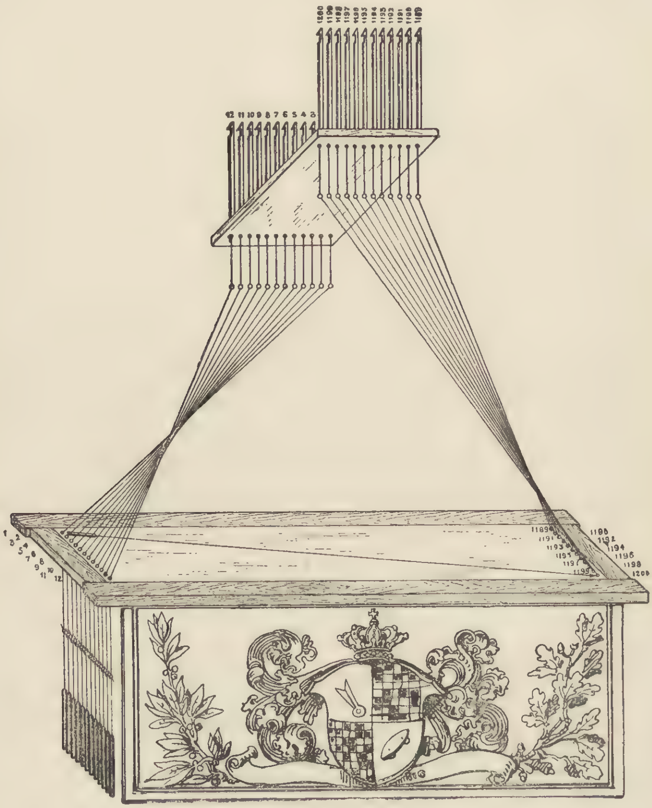

FIG. 18.

mails, and on the right is shown the design to be reproduced. For this a single harness is necessary owing to the varied character of the figuring throughout the whole width.

Assuming now that the fabric as shown contains 1200 warp

ends and is 24 ins. wide, there will then be 50 ends to the inch; and if each dent of the reed is to take 4 ends there will be $12\frac{1}{2}$ four-end dents per inch. With regard to the setting of the cords in the comber board, this will be discussed a little later on.

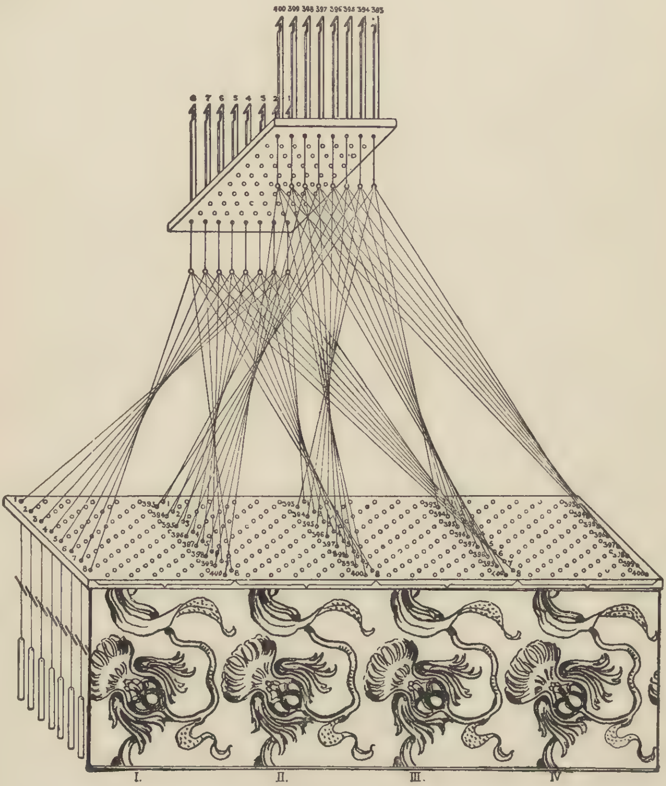

Fig. 19.

Usually, however, the regular harness is of the multiple cord type.

The dimensions of the machines used for this purpose are partly dependent on the pattern to be woven, also on the closeness of the warp setting, and finally on the total number of

warp ends used. In order to understand this better, we must consult Fig. 19, which represents a design containing 4 repeats. Here it is unnecessary to have a Jacquard machine large enough to lift each warp end separately from the rest, it being sufficient for the machine to be capable of dealing with a single repeat, in this case $\frac{1}{4}$ the entire width. All that is then necessary is to attach 4 cords to each of the hooks, the latter accomplishing the same task four times over at each lift. If 5, 6, or even more cords be attached to each hook, the work done by each will be increased in proportion.

As can be seen at the top or in the comber board, a 400-hook machine is provided in this case, and therefore the number of ends or cords required for the four repeats of pattern will be $4 \times 400 = 1600$. If the number of repeats were doubled, then each hook would have to carry twice as many cords.

Should it be desired to extend the scope of each repeat to say 600 ends, then a correspondingly larger machine, *i.e.*, one with 600 hooks would have to be employed.

Calculating Central Tie Harness.

To better understand this device the reader should turn to Fig. 20, the lower portion of which indicates the pattern to be woven. It will then be seen that the pattern is identical on either side of the centre, and it will thus be clear that both sides of the pattern can be produced by means of the same cords. The comber board shows that a 600-hook machine is used.

The manner of drafting the harness in the comber board is as follows: commence at 1 and proceed to 600, then, reversing the process, work back from 600 to 1. If the design is to be repeated 6 times in the width, the number of cords required will be $600 \times 2 \times 6 = 7200$, and 12 cords will have to be attached to each hook. In the figure, however, since there is only one repeat only 2 cords are attached to a hook.

On the comber board the No. 600 is shown twice. In practice, however, this must not happen or a double thread will

appear at this place. Consequently one of the cords No. 600 is left empty, or else only half the usual number of cords are attached to the corresponding hook. When more than one repeat comes in the width of the fabric, the same procedure

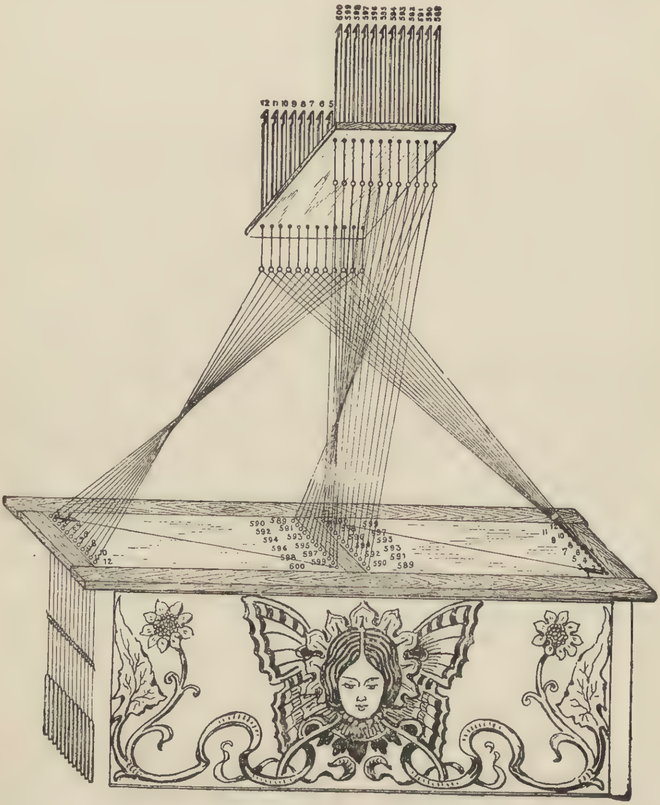

FIG. 20.

must be adopted with hook No. 1. The serial order of the drafts in the comber board is indicated by numbers and arrows. According as this arrangement is worked in conjunction with or without tringles, it is suitable for the production of carpets, bed covers, hangings, table slips, upholstery goods, etc.

Calculating Bordering Harness.

Border is the term applied to stripes placed at one or both edges of the fabric, and serving both as a decoration and as an edging for the whole. This class of decoration is chiefly applied to carpets, hangings, table cloths, bed covers and panneaux.

Fig. 21 represents a portion of a fabric with a border on

Fig. 21.

Borde = Border. Bruchteil des inneren Gewebes = Portion of centre pattern.

the left hand, and similar borders are woven at both ends of carpets, bed covers and table cloths, as well as at the two sides. When a Jacquard machine of sufficient size is available, a certain number of hooks are set aside for the border, and a portion or all the rest are used for weaving the centre pattern.

In the present instance let it be assumed that the Jacquard is an 800-hook machine, the whole of which are to be utilised as far as possible. The question then arises, what arrangement is to be adopted?

A closer examination of the central pattern reveals an exact duplication on either side of the middle line, and consequently a centre tie can be employed for this portion of the fabric. For the borders, on the other hand, except for the general edgings, each cord or warp end must be lifted independently for each side.

The machine being one of 800 hooks, the division will give 460 hooks for the borders and 340 for the centre pattern, and each of the latter must lift 2 cords in each repeat. Then, if there be 4 repeats in the width, there will be required :—

1. For the border on the left, 460 cords or ends.

2. For the four centre repeats of each, 340 × 2 = 2720 cords or ends.

3. For the right-hand border another 460 cords or ends.

From the 2720 centre ends, 7 must be deducted to prevent doubling, as already explained. Now, assuming the total width of the fabric to be 40 ins., each of the borders will measure 6 ins., *i.e.*, 12 ins. for the two, leaving 28 ins. for the centre.

Each hook from 1 to 460 must carry 2 cords, or together	920
Hook 461 must carry 5 cords	5
Hooks 462-799 must each carry 8 cords, or together .	2704
Hook 800 must carry 4 cords	4
Total	3633

Of the 5 cords attached to hook 461, 1 each is allotted to the first three repeats, and 2 to the fourth one, since this also being next the border can be reduced.

Calculating Harness for Striped Fabrics.

In patterned dress goods and occasionally also in table cloths, bed covers and hangings, striped patterns are often popular, in which event compound harness must be employed in order to keep the size of the machine within reasonable limits.

Example 1.—Take the case of a fabric with 3 figured stripes in conjunction with a small ground weave of 90 ends each, and assuming that the stripes must be arranged in the following order :—

	Ground.	Stripes. No. 1.	No. 2.	No. 3.
90 ends for ground . .	90	—	—	—
60 ,, stripe No. 1 . .	—	60	—	—
90 ,, ground . .	90	—	—	—
90 ,, stripe No. 2 . .	—	—	90	—
90 ,, ground . .	90	—	—	—
120 ,, stripe No. 3 . .	—	—	—	120
90 ,, ground . .	90	—	—	—
90 ,, stripe No. 2 . .	—	—	90	—
Ends . .	360	60	180	120

For each repeat of the pattern we have, therefore, 720 ends of warp.

If the width of the fabric be $51\frac{1}{4}$ ins., and the reed have $22\frac{1}{2}$ five-end dents per inch, how many cords must be attached to a hook in a 400 Jacquard machine, and what will be the best method for tying?

A $22\frac{1}{2}$ five-end dent reed for $51\frac{1}{4}$ ins. cloth will give 5760 ends, and as each full repeat of the pattern takes 720 ends, there will be exactly $5760 \div 720 = 8$ complete repeats in the full width.

In each repeat of the ground weave there are 360 ends, and, therefore, for 8 repeats . .	$360 \times 8 = 2880$
In each repeat of No. 1 stripe are 60 ends, and, therefore, for 8 repeats . . .	$60 \times 8 = 480$
In each repeat of No. 2 stripe there are 180 ends, and, therefore, for 8 repeats . . .	$180 \times 8 = 1440$
For No. 3 stripe there are 120 ends per repeat, and, therefore, for 8 repeats . . .	$120 \times 8 = 960$
Total number of ends . .	5760

Since there are 90 ends for each ground, we may take for these	90 hooks
For stripe No. 1 we may take . . .	60 ,,
,, No. 2, both stripes being equal .	90 ,,
,, No. 3	120 ,,
Together . . .	360 hooks

The remaining 40 hooks will, therefore, be left empty. The front 90 hooks will each have to carry 32 cords, and the remaining 91-150 will carry 8 cords each. To the next 90 hooks, Nos. 151-240, will be attached $8 \times 2 = 16$ cords apiece, and to the succeeding 120 hooks, Nos. 241-360, 8 cords each, leaving the final 40 empty.

Calculating Divided Harness.

In divided harness each division produces a more or less independent figuring effect or weave.

Example 1.—Assuming there is to be woven a piece of upholstery goods with 3 divisions, of which No. 1 has to produce the ground weave and the other two the figuring, the drafting being as follows :—

1 end of ground weave.
1 ,, figuring warp No. 1.
1 ,, ground.
1 ,, figuring warp No. 2.

The Jacquard is a 600-hook machine, the warp setting $137\frac{1}{2}$ ends per inch, and the width of the cloth 48 ins. How many ends must be allotted to each division, and what is the best method of tying to adopt ?

The total number of warp ends in the cloth is $137\frac{1}{2} \times 48 = 6600$. Of these one-half, or 3300 ends, go to the ground weave, and the balance is equally distributed between divisions 2 and 3, *i.e.*, 1650 to each. The tying of the Jacquard will then be as follows :—

300 hooks (Nos. 1-300) for the ground weave, division 1,
150 ,, (Nos. 301-450) ,, ,, ,, 2, and
150 ,, (Nos. 451-600) ,, ,, ,, 3.

Hence each hook in div. 1 must carry $3300 \div 300 = 11$ cords,
,, ,, ,, 2 ,, $1650 \div 150 = 11$,,
,, ,, ,, 3 ,, $1650 \div 150 = 11$,,

and hooks Nos. 1-300 will have charge of the ground weave,
,, Nos. 301-450 ,, ,, ,, figuring warp 1,
,, Nos. 451-600 ,, ,, ,, ,, 2.

Calculating the Tie in the Comber Board Itself.

This is an extremely simple matter. In the first place one must be quite clear as to how many cords are to be taken for each row, whether 6, 8, 12, 16, 20, 24, or even more. The number of course depends on the setting of the warp and the number of leaves in the comber board.

Example 1.—Take the case of a harness which has to be mounted with 8640 ends in a width of 72 ins., with 24 cords in each row. The question then is, how many rows of cords must be set to the inch?

The number of cords required is 8640, and these have to be distributed in 24 parts, so that we obtain $8640 \div 24 = 360$ rows; and since these 360 rows correspond to 72 ins. of width, there will be $360 \div 72 = 5$ rows in each. The number of holes in the comber board being usually more than is necessary, it will be the task of the weaver to distribute these 5 rows as uniformly as possible over each inch.

Allocating the Cords to be Left Empty in Tying a Harness.

First of all it must be stated that, where experimental looms are in question, the number of cords selected per repeat should be one that can be divided into the largest possible number of factors. Thus in the case of a

100-hook	machine	the best number	is 96
200	,,	,,	,, 192
300	,,	,,	,, 288
400	,,	,,	,, 384
500	,,	,,	,, 480
600	,,	,,	,, 576

Example 1.—A sample warp set in a reed with $22\frac{1}{2}$ four-end dents per inch is to be woven to 32 ins. cloth in an experimental loom fitted with a 200-hook machine. How must the warp be tied in order that different styles of weave may be tried, and assuming that there are 20 repeats of 192 cords each?

The entire harness contains 20 repeats of 192 cords each, or a total number of 3840 cords. The sample warp is to be drafted to 32 ins. in a reed with $22\frac{1}{2}$ four-end dents per inch, so that $22\frac{1}{2} \times 4 \times 32 = 2880$ cords will be required. If, as already mentioned, it be desired to try several different kinds of weave with this warp, it is advisable to employ a tie of 192 cords per repeat. In this case the 2880 cords will give us $2880 \div 192 = 15$ repeats; but as there are 20 repeats in the harness, 5 single repeats will have to be left entirely empty, and, of course, these should be distributed as uniformly as possible over the full width, *e.g.*, as follows:—

$$\begin{array}{lll} 1 & \text{repeat} & \text{tied.} \\ 1 & ,, & \text{left empty.} \\ 2 & ,, & \text{tied} \\ 2 & ,, & \text{left empty} \\ 2 & ,, & \text{tied.} \end{array} \quad \begin{array}{l} \\ \\ \left.\begin{array}{l} \\ \\ \end{array}\right\} \text{4 times over.} \\ \\ \end{array}$$

EXAMPLE 2.—In this case we will assume the loom to be fitted with a 400 machine, with 14 repeats of 384 cords each, over a width of 36 ins., and that the warp is to be tried in a thirty-end weave 36 ins. wide, the reed containing 15 eight-end dents per inch. What is the best method of tying to secure the best possible distribution of the ends, and what will be the most suitable number of cords to use?

The harness contains 14 repeats of 384 cords each, or 5376 cords in all, and the number of cords needed to make the desired pattern is $15 \times 8 \times 36 = 4320$. Now, in order that the warp may weave easily and with a minimum of chafing against the empty cords, it should be distributed as uniformly as possible, and it is, therefore, advisable to distribute it among all 14 repeats. If it were possible to tie an equal number of ends in each repeat, the number of cords required would be $4320 \div 14 = 390$ in each repeat; but since the pattern is to be 30 ends wide, we must choose a number that is divisible by this figure. Now the nearest number of this kind to 309 is 330, which would give us 4620 cords, or 300 cords too many, whilst, on the other hand, the next suitable number below 309 is 300, which, however, would give only 4200 cords,

or 120 too few. Hence, since neither of these two numbers taken alone will give the desired result, it is necessary to combine them as follows :—

Repeat	No. 1 tie	300 cords.
,,	No. 2	300
,,	No. 3	330
,,	Nos. 4 and 5	300 each.
,,	No. 6	330
,,	Nos. 7 and 8	300 each.
,,	No. 9	330
,,	Nos. 10 and 11	300 each.
,,	No. 12	330
,,	Nos. 13 and 14	300 each.

Neither 300 nor 330 is a favourable number for an experimental loom, owing to the small number of divisors exhibited by each. Thus 300 is divisible only into 2, 3, 4, 5, 6, 10, 12, 15, 20, 25, 30, 50, 100 and 150, whilst 330 cannot be divided into more factors than 2, 3, 5, 6, 10, 15, 30 and 165. On combining the two we obtain only the following factors common to both, 2, 3, 5, 6, 10, 15 and 30, none of which however are very frequently met with in small patterns. On the other hand, 360 would be a far more appropriate figure, since it gives the factors 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30, 40, 60, 72, 90, 120 and 180—all numbers in everyday use.

Accordingly it is better to employ the figure 360, and to leave a couple of repeats quite empty, placing them out of the way in a reserve box at the rear of the comber board. The number of complete repeats of 360 cords required is ascertained by dividing the number of threads (4320) by 360, which gives 12 as the answer. Since the full harness has 14 repeats, 2 will have to be left empty, and the best means of arranging this as follows :—

Tie 4 repeats of 360 cords each,
Leave empty 1 repeat,
Tie 4 repeats of 360 cords each,
Leave empty 1 repeat,
Tie 4 repeats of 360 cords each.

An alternative method, in view of its suitability for other classes of weave to be tried in the loom, would be to tie 8 repeats of 360 cords each, and 6 repeats of 240 cords each, arranged as follows :—

1 repeat of	360 cords.			
1	,,	240	,,	} 6 times.
1	,,	360	,,	}
1	,,	360	,,	

Calculating the Tie-up Plan.

The tie-up plan is a sheet of paper marked off in squares, on which the arrangement of the crossing threads of a given pattern or fabric is to be depicted.

For ordinary plain, unfigured fabrics it does not matter, so far as the ratio of warp and weft is concerned, how the plan is divided; but when figured patterns have to be reproduced and the contours sketched on the plan before marking the intersections, it is necessary that the proper proportions should be observed in order that the figures woven in the fabric may be symmetrical.

It therefore follows that the paper is not invariably marked off in squares, but often in parallelograms differing in height and breadth.

In addition to the actual squares themselves, there must be taken into consideration the division of the squares into groups of warp and weft respectively. The first of these groupings usually follows the arrangement of the pushes in the card-cutting machine, or on the Jacquard machine itself if the cards are not cut by electricity, and the second grouping depends on the relation of the weft to the amount of the warp.

The object of this division of the squares into groups is to assist the card cutter in determining which keys are to be depressed in the cutting machine, and finally to facilitate the determination of the ratio of warp and weft.

The paper most largely employed is that in which the proportions of warp and weft are identical. If such a paper is divided into groups of 8 squares each way it is termed 8 × 8

paper; if there be 8 squares in the width and 12 in the length it is called 8 × 12 paper, and so on.

The paper selected for a 600-hook machine which usually has 12 hooks in a row will be one in which the groups consist of 12 squares wide. Should this paper have, as stated, 12 squares in the width of each group and only 10 in the length, it is called a 12 × 10 paper, the dimensions relating to the warp being always given first.

The ratio of weft to warp depends on:—

(1) The price at which the fabric is to be sold;

(2) The class of weave; whether the warp or weft is to play the principal part, or whether both appear uniformly on the face;

(3) The arrangement of the tie-up plan and the cutting of the cards; and finally

(4) The count of yarns used.

EXAMPLE 1.—Suppose we have a comparatively fine warp and desire to use $\frac{1}{4}$ less of this than of a weft of same count, what paper must be taken for the tie-up plan of a 400-hook Jacquard or for each 8 rows?

If the warp and weft threads were equal in number an 8 × 8 paper would be used. In the case under consideration, however, the warp threads are 25 per cent. less in number than the wefts, and the deficiency has to be made good by weft, that is to say, we require for the fabric $\frac{3}{8}$ in warp and $\frac{5}{8}$ in weft. If we needed an equal number of warp ends, *i.e.*, $\frac{4}{8}$ of the whole, the No. 8 paper must be grouped in 8 weft squares as well, and if only $\frac{1}{8}$ of the whole were weft the paper would have to be $\frac{8}{4}$ in the weft; consequently if $\frac{5}{8}$ of the fabric is to be weft the division will have to be $\frac{8 \times 5}{4} = 10$, that is to say, an 8 × 10 paper must be used.

EXAMPLE 2.—According as a warp or weft effect is to be produced, so will the warp require to be set in proportion, and a suitable paper taken for figured patterns. If the warp is to play the chief part on the face it must be set closer than the weft and *vice versâ*.

Assuming then that 80 warp ends are to be set per inch

and 70 picks in the same unit of length, what paper must be taken for a 400-hook machine?

If an equal number of warp and weft threads had to be set per inch, the paper required would be one with 8 squares each way in the group, but as the ratio of warp to weft is 80 : 70, we require for the weft a paper with $\frac{8 \times 70}{80} = 7$ squares, *i.e.*, an 8 × 7 paper.

EXAMPLE 3.—A tie-up plan is to be drawn for a 600 machine with 60 ends of warp and 80 picks of weft per inch. What paper must be used, the Jacquard being a 12-row machine?

If the number of ends and picks were equal, *i.e.*, 60 per

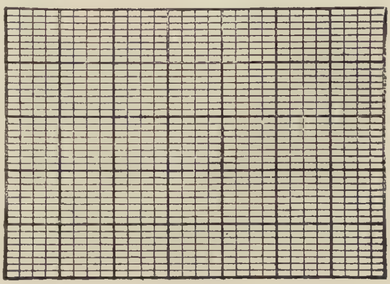

FIG. 22.

inch, a 12 × 12 paper would be required, but as the proportion of warp to weft is 60 to 80, we must procure a paper with (12 × 80) ÷ 60 = 16 squares in the weft, *i.e.*, a 12 × 16 paper.

EXAMPLE 4.—In example No. 3 when the nature of the drawing and the conversion of same into a card pattern are in question, much depends on whether the fabric is woven with one or more warps or wefts, and whether each of these threads shall be separately indicated, or if the effect of all threads in the same line is denoted by a special mark.

The latter is the general rule, and then all that is necessary is to determine the warp-weft ratio beforehand, and proceed as in the foregoing examples. Should a filling or back weft have

to be inserted, and this cannot be properly shown in the drawing for the face, it will be necessary to change the paper accordingly. Sometimes the paper used contains three times as many squares in the height as it does in the width.

EXAMPLE 5.—With regard to the count of the yarns let us assume that a No. 21 warp and a No. $12\frac{1}{2}$ weft are in question, and that the amount of each in the fabric is to be the same. What paper must be used for a 600-hook, 12-row Jacquard ?

For warp No. 21 and a weft of equal thickness, a 12×12 paper would be needed, consequently for No. 21 warp and No. $12\frac{1}{2}$ weft we shall require a paper with $(12 \times 12\frac{1}{2}) \div 21 = 7$ squares in the weft, *i.e.*, a 12×7 paper.

A 4×8 paper is shown in Fig. 22.

SECTION II. (*Continued*).

CHAPTER IV.

FINISHING AND ESTIMATING FROM CUTTINGS.

Calculations in the Cloth-finishing Process.

Leaving out of consideration the loading ingredients occasionally added with fraudulent intent in the finishing process, the chief questions with which we have to deal in the milling process applied to many kinds of woollen goods are: 1. To what extent must a fabric of given weight be milled in order to produce a definite weight per yard? 2. What milling must be given to furnish a given length of finished cloth? In the latter contingency, the same lines can be followed as in the former, provided the piece—or at least the sample cutting of same—be previously washed and dried, and the amount of subsequent loss in milling, raising and shearing be accurately known.

The calculation of the shrinkage in the width is here left out of consideration in the case of a given piece of finished goods, inasmuch as it is invariably essential to finish the fabric to a marketable width.

Example 1.—Assuming we have a washed and properly dried piece of cloth measuring 57 yds. in length and weighing 67 lb. The loss in milling, raising and shearing is given as 8 per cent., and the finished cloth is to weigh $18\frac{3}{4}$ oz. per yard. To what extent (percentage) is the piece to be milled?

The total weight being 67 lb. and the loss in finishing 8 per cent., the loss of weight will be $(8 \times 67) \div 100 = 5\cdot36$ lb., and the net weight of the finished piece $67 - 5\cdot36$ lb. $= 61\frac{5}{8}$ lb. Since the net weight per yard is to be $18\frac{3}{4}$ oz., the final measurement of the piece will be $(61\frac{5}{8} \times 16) \div 18\frac{3}{4} = 52\frac{3}{4}$ yds. The

shrinkage in milling is thus $57 - 52\frac{3}{4} = 4\frac{1}{4}$ yds. or $7\frac{1}{2}$ per cent.

The goods may stretch again by a few units per cent. when exposed to strong usage in the raising machine, and when heavy pressure is applied in beetling. As a rule, however, they contract once more to the same extent in steaming, provided the tension employed in the former processes has not been excessive.

Calculating the Loss of Weight in Finishing Woollens.

This loss cannot be accurately estimated beforehand, owing to the numerous factors on which it is dependent, *viz.* :—

1. On the staple and quality of the raw material.
2. On the method of treatment adopted in scouring, dyeing and spinning.
3. On the larger or smaller percentage of oil and other impurities in the goods.
4. On the regularity and extent of the milling process, and whether the goods are kept properly moist or too dry in milling.
5. On the degree to which the goods are raised and shorn if at all.

For these reasons, therefore, only average percentages can be estimated, the following list giving, in the author's opinion, the most nearly approximate figures :—

Woollen goods, piece dyed	20	per cent. in all.
,, ,, dyed in the wool	18	,,
Eskimo I., piece dyed	24	,,
,, I., dyed in the wool	20	,,
,, II. and III., piece dyed	30	,,
Worsteds, pure, piece dyed	10	,,
,, ,, dyed in the wool	8	,,
,, with filling weft, piece dyed	16	,,
,, ,, dyed in the wool	14	,,
,, with back weft, piece dyed	25	,,
,, ,, ,, dyed in the wool	22	,,

Cheviots same as worsteds.

Calculating Weight of Fabric from a Small Cutting.

It is a common thing for a manufacturer to receive from a customer a small cutting of a fabric with an inquiry as to the cost. If the maker produces similar goods it will be easy to quote a price after examining the sample.

Formerly when profits were larger it was unnecessary to go so closely into calculation, a small margin either way making but little difference; but, unfortunately, nowadays, when profits are reckoned by fractions of a penny, the case is otherwise.

If the manufacturer were able to form an accurate judgment of the count of yarn by mere inspection, he could easily determine the weight of the fabric by multiplying the yarn numbers on the number of warp and weft threads. The best method, however, to arrive at an accurate result is to weigh the sample and from this calculate the weight per yard. This simple process is elucidated in the following examples:—

Example 1.—The sample under examination measures 3 ins. by 4 ins., and weighs $\frac{1}{10}$ of an ounce. What will be the weight of the 56 ins. cloth per yard exclusive of selvages?

The dimensions of the sample are $3 \times 4 = 12$ sq. ins., and since a yard of the cloth contains $36 \times 56 = 2016$ sq. ins., the weight will be $\frac{2016}{12} \times \frac{1}{10} = 16\frac{3}{4}$ oz., or including $\frac{1}{4}$ oz. per yard for the two selvages, a total of 17 oz. per yard.

Example 2.—The sample is triangular in shape, measuring 4 ins. in one direction, 5 ins. in the other, and weighing $\frac{1}{8}$ oz. What will be the weight of the 56 ins. cloth per yard?

The dimensions of the cutting are $5 \times 4 \div 2 = 10$ sq. ins., and as the weight is $\frac{1}{8}$ oz. and the yard contains 2016 sq. ins., the weight of the goods will be $\frac{2016}{10} \times \frac{1}{8} = 25\frac{1}{4}$ oz. per yard, or with an addition of $\frac{1}{4}$ oz. for the selvages, $25\frac{1}{2}$ oz. per yard.

If it be desired to estimate the amount of oiled yarn required to produce the goods, the corresponding percentage of loss in finishing must be added from the table already given.

Calculating the Yarn Number from a Cutting when the Number of Warp and Weft Threads can be Counted.

In matching a sample of goods, the yarn number plays a by no means unimportant part both in connection with the setting to secure the same appearance, and also with regard to the price and weight of the goods.

An old hand very often succeeds in estimating the count of yarn with considerable accuracy by simply looking at the sample, but it is difficult for a beginner or less skilled eye to come anywhere near the truth by this means. If the warp and weft threads are of equal thickness, it is easy to ascertain the count by the aid of an accurate balance, but when they are of different thickness it becomes necessary to examine each separately. The same also applies when more than one count of yarn is found among the warp or weft threads.

Example 1.—A sample of worsted dyed in the wool measures $1\frac{3}{4}$ by $3\frac{1}{2}$ ins., contains 414 warp threads and 220 weft threads of equal count and weighs 0·04 oz. What is the count of yarn used, assuming a loss of 8 per cent. to have been sustained in finishing?

The total length of the warp threads is $416 \times 1\frac{3}{4}$ ins. = 728 ins., and of the weft threads $220 \times 3\frac{1}{2}$ ins. = 770 ins., together 1498 ins. or 41·6 yds.

Since the loss of weight in the finishing process is taken as 8 per cent., the weight 0·4 oz. represents only 92 per cent. of the original weight, which will therefore be $(100 \times 0{\cdot}0416) \div 92 = 0{\cdot}0522$ oz. And since 0·0522 oz. of the yarn measure 41·6 yds., 1 lb. will measure $(41{\cdot}6 \times 16) \div 0{\cdot}522 = 12750$ yds., *i.e.*, the yarn number is 23. Being doubled yarn, however, the real number is 46/2's.

Example 2.—The weft threads in the sample are decidedly coarser than the warp, and in each case a length of 10 ft. of yarn is obtained by dissecting the sample and laying the threads end for end. The 10 ft. of warp weigh 0·007 oz. and the 10 ft. of weft 0·009 oz. What count of each yarn has been

used, assuming the loss in finishing to amount to 18 per cent.?

Since the 10 ft. of warp yarn weigh 0·007 oz., and the loss of weight in finishing is assumed to be 18 per cent., the original weight of the warp yarn would be $(0·007 \times 100) \div 82 = 0·00853$ oz., and as this is the weight of 3·33 yds., 1 lb. of the yarn would measure $(3·33 \times 16) \div 0·00853 = 6246$ yds. Hence the yarn number for the warp is $6246 \div 560 =$ No. 11.

In the weft yarn the 10 ft. weigh 0·009 oz., and as here also the loss in finishing has been 18 per cent. the original weight of the weft would be $(0·009 \times 100) \div 82 = 0·011$ oz. This weight measuring 3·33 yds. of yarn, 1 lb. would measure $(3·33 \times 16) \div 0·011 = 4844$ yds., and the yarn number would, therefore, be $4844 \div 560 =$ No. $8\frac{1}{2}$ weft.

If more than one count of yarn has been taken for either warp or weft, each kind will have to be separated from the rest and calculated by itself in the above manner.

Determining the Yarn Number of a Given Sample by Comparison.

When an approximate idea of the count of a sample of yarn is desired, and standard specimens of yarn are available for comparison, a very simple method is frequently practised, and the same is also applicable when different yarns from the same specimen of cloth are to be compared.

With this object several (6, 8, or more) threads of the two yarns are taken and linked together in the middle, as shown in Fig. 23, after which they are twisted with the thumb and index finger. If both yarns are of the same count, the resulting twists will be of equal thickness, and can be tested with the thumb and finger as well as with the eye. Should there be any appreciable difference the number of threads on either side can be increased or diminished until equality of thickness is attained, and when this is done the calculation of the yarn number becomes an easy matter.

Example 1.—In testing a sample of yarn by the foregoing

method it is found that 12 ends of the new yarn give a twist of the same thickness as that furnished by 10 ends of a No. 45/2's ($22\frac{1}{2}$ singles). The ratio between the two is, therefore, 12 : 10, and the count of the test yarn is $\frac{22\frac{1}{2} \times 12}{10} = 27$, *i.e.*, the yarn is either a No. 27 singles or No. 54/2's.

EXAMPLE 2.—In comparing two other yarns we find 7 ends of the one under examination are equal in thickness to 12 ends of No. 52/2's, or 26 singles. According to this ratio the count of the test yarn is $\frac{26 \times 7}{12}$ = No. 15 singles, or 30/2's.

EXAMPLE 3.—Sometimes a singles yarn has to be compared with a twist, which is not so easy to do with the naked eye,

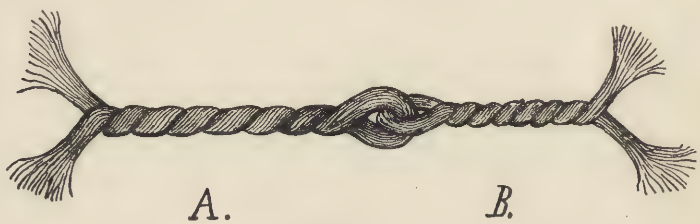

FIG. 23.

since single yarns are not usually so tightly twisted as doubled ones, especially in the case of slack-twisted wefts.

The foregoing test will give more reliable results, provided the ends taken are twisted very tightly together. Suppose 6 ends of the singles yarn under examination give the same thickness of twist as 10 ends of No. 36/2's (= 18 singles), then the yarn number will be $\frac{18 \times 6}{10}$ = No. $10\frac{3}{4}$.

COST OF FINISHING CLOTH.

The costs of sorting, scouring, carbonising and drying wool, spinning and weaving, have already been given. As regards the finishing process, the complex nature of the operations results in a considerable divergence in the cost of the products,

the latter working out higher in proportion as the amount of labour, time, wear of machinery, consumption of soap, soda, raising cards, steam, water, etc., increases. Hence it is impossible to fix any universal rate.

In some manufacturing centres the cost is reckoned at so much per piece, in others at a certain rate per yard, the latter being of course the only proper way, since it cannot be imagined that a piece of cloth 50-60 yds. in length could be finished for the same money as one only 30 yds. long. Conversely, it cannot be supposed that the manufacturer is willing to pay the same price for short pieces as for long ones, especially as the cost of finishing is an important item in the price of the goods.

According as goods of one quality or another require more careful treatment, so will the cost of finishing vary for one and the same class of article.

The following rates are generally taken to represent the cost of finishing the goods specified :—

Piece-dyed Cheviots . .	$2\frac{3}{4}$d.-$3\frac{1}{4}$d. per yd. of finished cloth.
Wool-dyed ,, . .	$2\frac{3}{8}$d.-$3\frac{5}{8}$d. ,, ,, ,,
Piece-dyed worsteds, shorn .	$3\frac{3}{8}$d.-5d. ,, ,, ,,
,, ,, drapes .	5d. -$6\frac{5}{8}$d. ,, ,, ,,
Wool-dyed ,, . .	$3\frac{7}{8}$d.-5d. ,, ,, ,,
Eskimo and dress materials .	$4\frac{1}{2}$d.-$5\frac{1}{2}$d. ,, ,, ,,
Mesh fabrics . . .	$5\frac{1}{2}$d.-6d. ,, ,, ,,

Of the rates in connection with half-woollen goods which cost 1d.-$1\frac{3}{8}$d. for finishing, nothing further need be said.

Cost of Dyeing.

The following table (p. 100) gives the rates agreed on by the Aachen Dyers' Convention, and, in fact, represents the practice generally observed at the present time :—

Rinsing from the blue is paid for at the rate of	1s. per piece.
,, all bright colours	9d. ,,
,, ,, other colours	1s. 6d. ,,
Mordanting	2s. ,,

Spotting out is reckoned as mordanting, except for half-woollens.

	Heavy Woollens (like Eskimos), Doubles, Paletots, Beavers, Satins, etc.[1] Shillings per cwt.		Worsted with Inferior Back Weft and Cheviots weighing over 45 lb., and all Worsteds over 65 lb. Shillings per cwt.		All other Goods. Shillings per cwt.	
	s.	d.	s.	d.	s.	d.
Black . . . . . net.	16	6	18	0	20	0
Bright blue . . . . ,,	20	0	21	0	22	6
Wood blue . . . . ,,	22	6	24	0	25	0
Navy blue, topped with wood . ,,	30	0	30	0	32	6
Unblued blue, fast to wear . . ,,	32	6	35	0	37	6
Blued blue and anthracene blue . ,,	40	0	42	6	45	0
,, fast to acid and wear, and pure alizarine blue . . ,,	55	0	55	0	60	0
Brown and olive . . . ,,	22	6	25	0	30	0
Alizarine brown and olive . . ,,	35	0	37	6	40	0
Wood green and acid green . ,,	22	6	25	0	30	0
Fast green . . . . ,,	40	0	42	6	45	0
Mode colours . . . . ,,	30	0	40	0	50	0

[1] Combed woollens are not included in this category.

SECTION III.

CALCULATING THE FULL COST OF GOODS.

CHAPTER I.

Preliminary Remarks.

In addition to the cost of the raw materials and various manufacturing operations it is necessary, in order to arrive at the full cost of the goods, to make allowance for general and special working expenses, and then add the profits so as to obtain the selling price. For the following reasons it is impracticable to arrive at any accurate standard for these items :—

1. One manufacturer works with his own, perhaps large, capital, whilst another operates partly or entirely with borrowed money or funds belonging to other parties.

2. In some cases the works are situated in the country, where cheap labour is the rule, whereas in others the factory is in a town, where rent, working expenses, etc., come higher.

3. One manufacturer owns his working premises; another is merely a lessee.

4. In one place cheap water or other motive power is available, whilst in another the more or less expensive sources of power, coal, steam or electricity have to be employed.

5. Again, one manufacturer disposes of a supply of pure, soft water for scouring, dyeing and finishing, whilst another has to purchase every drop of water consumed, and then obtains water that is more or less hard, which increases the consumption of soap and detergents.

6. One manufacturer works with cheap, out - of - date

machinery, whilst another makes use of new or improved plant capable of giving a much larger output for the same outlay in wages and power. Thus, one manufacturer's looms make only 50-60 picks a minute, whereas those of another run at speeds of 80, 90, or even as high as 120 picks per minute, and so on.

7. One manufacturer is more highly taxed than another. For instance, German manufacturers at present have to contribute to invalid funds, accident insurance, sick funds, etc., from which their competitors in other lands are exempt.

These imposts at present amount to about 1s. 6d. on a 45 yd. piece of cloth worth 4s. 6d. per yd., so that an allowance of about 0·73 per cent. has to be made for these contingencies in calculating the cost of cloth. This estimate is based on an instance where the total contribution to the aforesaid funds amounted to 4493 marks (shillings) in a factory turning out 2844 pieces of cloth.

Such items of expense are unknown to makers in other countries except by name. A further disadvantage sustained by the German manufacturer is that the weavers are strenuously opposed to minding more than one loom, whereas in other producing centres the system of placing two looms under the charge of one operative is largely practised.

8. One manufacturer supplies tailors, and sells a few pieces at a time, another sells to retail houses, and a third caters exclusively for the large wholesale trade.

9. One manufacturing house does business through cheap commission agents, whilst another employs its own travellers during the season or all the year round.

10. One maker sticks to a certain range of stock goods, whilst another goes in for fashionable articles, either partly or entirely. In such case the former has less expense in getting up samples than the latter, who has to pay a high salary to his designer, and has besides to employ a number of pattern weavers and keep a large stock of patterns and yarns.

11. One manufacturer produces none but piece-dyed goods, another has all his dyed in the wool.

12. In one factory woollens or Cheviots alone are made, in another fine worsteds are produced. In the latter case the fineness of the yarns militates against a large output; hence the turn-over is more gradual.

In coarse yarns the charges for spinning and weaving are also lower than those for higher counts.

13. Some manufacturers have to employ a manager, etc., whilst others are in a position to look after things themselves and place the supervision of minor matters in the hands of relatives.

14. One factory is near the main arteries of traffic, railway or port, whereas another has to provide expensive cartage.

15. One manufacturer buys his raw material, yarn, coal, etc., direct and in large quantities, perhaps for cash, another enjoys only a small credit, and has to purchase on a less extensive scale.

16. One manufacturer will have nothing but the best quality raw material, yarns and the like; another prefers cheaper stuff for the most part.

17. One carries on his business in an industrial centre where he can cover his requirements in raw material, yarns, mill sundries, etc., on the spot, and is also close to his chief customers; whilst another is isolated and out of touch with offers, inquiries and improvements.

18. One maker has all his work done outside at certain rates, another merely weaves, a third both weaves and finishes, a fourth weaves, dyes and finishes, and a fifth spins, weaves, dyes and finishes on the premises.

A very troublesome factor in manufacturing and calculation is the irregularity with which customers settle accounts, an evil that is continually on the increase. In fact, many wholesale and retail houses and clothiers really work with the manufacturer's money by not paying for their purchases until they have resold the goods and received the money themselves. It frequently happens that, after enjoying six or even nine months' credit, a customer will deduct 4-6 per cent. in settling a manufacturer's account, apart from all possible claims for

allowance on the score of small defects, etc. Now the manufacturer on his side has to pay for his raw materials, machinery, etc., at fixed prices, and for his labour in cash. If he complains to his customer, the latter throws the blame for the delay on to *his* customer, who in turn blames a fourth party, and so on. In any event, the manufacturer suffers the greater injury, and in cases of bankruptcy loses the most money. The eternal credit system, coupled with all manner of chicaneries in respect of discounts, the custom of furnishing large sample cuttings free of charge, etc., are cankers eating into the entire textile industry and inimical to the manufacturer and the business he represents.

Various Factors to be Considered in Calculation.

1. The quantity of material consumed, in this case wool or yarn.

2. The loss of raw material in scouring, spinning, beaming the warp, weaving and finishing, as well as warp and weft contraction in the loom, and finally the shrinkage in finishing.

3. The direct charges paid for sorting, scouring, carbonising, drying, and eventually for dyeing the wool; spinning, and eventually doubling the yarn, beaming, sizing, drying, tying up; then weaving, nopping, finishing, carbonising, and eventually dyeing the goods.

4. Salaries for general manager, managers of the spinning and weaving departments, loom setter, clerks, harness girls, pattern weavers, overseer and examiner in the nopping and darning room; foremen in the scouring, milling, raising, shearing and other branches of the finishing department, travellers, doorkeeper, charwomen, stoker, night watchman, etc.

5. Additions for sundries, such as coals, faggots, lubricating oil, cleaning rags, emery cloth, tools, driving belts, packing cases, baskets, boxes, tin and paper cylinders, card furniture, driving cords, ropes, sewing twine, wool-softening oil, size, harness, reeds, laths, shuttles, drivers, driving rods, Jacquard cards, sample yarns, gum, nopping irons, darning needles,

chalk, sewing silk, soda, soap, water, raising cards, benzine, packing paper, pens, ink, stamps, account books and pattern albums, specimen cards, packing cloth, boards, string, etc., etc.

6. So-called general expenses, comprising :—

(*a*) Interest on the necessary working capital.

(*b*) Rent.

(*c*) Depreciation and maintenance of plant, buildings, machinery and fittings.

(*d*) Lighting and heating.

(*e*) Samples.

7. Sundry contingencies, *e.g.* :—

(*a*) Delay in settling accounts by customers.

(*b*) Agents and commissions.

(*c*) Expenses attendant on samples.

(*d*) Interest on cost of material during the time occupied in working up.

(*e*) Any eventual sudden rise in the price of materials.

(*f*) Defective goods.

(*g*) Remainders.

(*h*) Banker's discount and charges, losses in exchange, accident, invalid and fire insurance, sick funds and sundry small expenses.

(*i*) Freight and packing.

(*j*) Profit.

(*k*) Discount to customers.

The first item in this list has been fully discussed in the earlier parts of the book, and item 2 has already been partly dealt with. As regards the loss of warp and weft, the allowance made on this score in the calculations hereinafter detailed varies from 2½ to 6 per cent. according to the material in question, 2½ per cent. being allowed for ordinary worsted, 3 per cent. for Cheviots, 4 per cent. for ordinary woollens and carded Cheviots, and 5-6 per cent. for goods with back weft.

To some readers these allowances may appear rather high, but it should be remembered that they include :—

(1) Broken and pieced warp ends.

(2) Warp thrums.

(3) Defective threads.

(4) Trial weaving at the beginning of the warp or pattern.

(5) Ravelled bobbins and cops.

(6) Yarn ravaged by moths.

(7) Badly wound bobbins.

(8) Yarn thrown off in weaving, especially when the shuttles strike rather too hard in the boxes.

(9) Unfinished bobbins.

(10) Waste yarn in unweaving weft smashes and other defects.

(11) Small remnants of yarn mostly fit for nothing but waste.

If all these factors be reckoned with, the percentages mentioned will be found practically irreducible on the average, for though in some cases they may be too high, in others again the loss will be greater. Besides there are so many unforeseen causes of loss, for which no provision has been made by the manufacturer in his calculations, or which have been set down at too low a figure. Imagine the position of the manufacturer who has made up his prices at the beginning of the season on a certain state of the wool or yarn market, and then, when the time comes for his orders to be supplied, finds that rates at the London auctions have gone up. Unless he is protected by contract with the wool or yarn merchant he will lose money on his sales, even though he has set down in his calculations a few units per cent. too much in one or other of the items.

Thus, in the case of weft the invariable allowance for contraction in the loom is 5 per cent. This may seem too high in some instances, but since the tension on the weft threads in weaving is not so great by far as that employed by the spinner in reeling the yarn, this figure is easily attained. Moreover the yarn rarely attains the proper count, but is usually coarser instead of finer than the given thickness.

On the other hand, the manufacturer if he be careful and possesses insight can easily control the percentage of contraction and the difference in the yarn count. In the first case all he has to do is to note and book the amount of yarn sold as cloth

during a given period, say twelve months, and compare the result with the quantity used. It is also easy to arrive at an average in respect of the deficiency in the yarn count, by multiplying the width of cloth (plus selvages) in the reed by the number of picks inserted, the answer revealing the percentage of loss. Of course this percentage varies according to the tension on the yarn, and whether the shuttle lies quietly in the boxes, or rebounds.

In the calculation given below, no allowance has been made for thrums left in the harness, because in an ordinary warp length of 5-7 pieces of cloth this item is so small as to be negligible.

Item 3. In respect of rates of payment, which play an important part in the cost of production, every manufacturer must base on the terms current in his district, or on those he actually pays. In some places, for instance, the average weaving price per 1000 picks is $1\frac{1}{2}$d., in others only $1\frac{1}{4}$d., and where the two-loom system is in vogue it may run as low as $\frac{3}{4}$-$\frac{7}{8}$d.

Moreover, as already mentioned, one manufacturer works with new and up-to-date machinery, whereas another employs old machines in producing his goods, the looms of the one inserting 100-120 picks a minute, while those of the other do not exceed a speed of 60-70.

As already mentioned, the rates for entering warps in the loom are $\frac{5}{8}$d. for white or single-colour goods, and $\frac{3}{4}$d. for multi-coloured goods or those with back warp. These rates apply to 2-piece warps, but are increased in proportion for 4- and 6-piece warps. In this way the attaching of the harness, entering in the reed, and chafing of reed and harness may be left out of calculation, the more so because—at the end of the season particularly—some of the warps are only for a single piece, and then the weaver must be paid an additional 5 per cent. for the whole.

Item 4. These particulars are easily estimated in the factory, and need not be discussed in detail here.

Item 5. It is impossible to quote definite figures applicable to all cases, and the task of fixing them as accurately as possible

must be left to the manufacturer himself. This may be done by booking the outgoings to separate accounts, totalling them at the end of the year, and dividing the result by the output.

It therefore follows that a period of at least a year is necessary for arriving at a definite average for purposes of calculation, but it is still better to take the mean of a series of years.

The same remarks equally apply to item 6, and also to 7 (*a-i*).

For the contingency of a sudden rise in the price of materials, an allowance of 2 per cent. is always made. At the first glance this may be thought excessive, but when the occurrences of recent years are borne in mind, where prices of yarns have been forced up 10-20 per cent., and even more in the middle of the season, 2 per cent. will be looked upon as, if anything, too small; in fact, some careful manufacturers reckon 6-10 per cent.

The allowance for defective pieces depends first of all on the class of goods made, then on the skill of the operatives, and finally on the efficiency of the supervision.

If a manufacturer keeps account of all the foregoing items—and the outlay on samples should by no means be forgotten—he will in time dispose of satisfactory data on which to base his calculations without risk of sacrificing his money and trouble.

SECTION III. (*Continued*).

CHAPTER II.

THE VARIOUS METHODS OF CALCULATION.

The calculation of a cloth can be worked out in different ways, but the following four methods are principally employed :—

1. The various items for materials and loss, preparing (beaming, sizing, drying, entering) the warps, weaving, nopping, mending, finishing, etc., are set down with the addition of the various percentages to cover salaries of manager and designer, cost of producing patterns, repairs, machine sundries, rent, etc. To the result are added the percentages accruing in respect of :—

Discount and delayed payments, agents' commission, cost of samples, loss of interest on material during manufacture, allowances for sudden rise in the cost of materials, defective pieces and remainders, bank charges, loss in exchange, various insurances, sick funds, general and petty expenses, packing and freight, and the whole is crowned by the addition of 8 per cent. or more as profit.

2. The second method of calculation which is largely employed consists in first reckoning items 1-3 at their actual value, and adding to the total a certain percentage founded on practical experience. This percentage is an average, which may be reduced somewhat in the case of simple fabrics that take less time and trouble than ordinary, and increased for high-class goods with close weft count of fine yarn. The same applies also to special mode fabrics with striking patterns that will be difficult to sell when out of fashion, and therefore the maker must protect himself by imposing an extra percentage.

The item of percentage addition mentioned in the first part of the preceding paragraph varies from 30-50 per cent.

3. The third and most convenient method of calculating is that employed in Belgium and a few other places, and consists in setting down the cost of the raw material, then the various fixed payments for labour, and adding to the product a certain sum including a definite rate of profit per yard. This sum varies according as the goods are easy or difficult to produce, with close or open setting and coarse or fine count yarns. Moreover, as in the previous method, an extra percentage is placed on mode fabrics that are hard to sell when the fashion is over, and the extra cost of patterns must also be taken into consideration in such cases.

4. In the fourth method the finished goods are carefully weighed and sold by weight, as is now generally the practice with felted fabrics whether woven or not.

Up to about thirty years ago it was still the custom in some centres to sell goods on the basis of weight exclusively, irrespective of the number of picks and count of yarn, but at that time competition was less keen and profits were higher than at present.

A curious but convenient method of calculating still practised in some cases is the following:—

The cost of the warp and weft yarns is first ascertained, the finishing is set down at twice the amount of cost, and finally about 2d. extra is added on each 1000 yds. of yarn consumed. For example, in the case of a yarn running 15,000 yds. to the lb. if 60 lb. were used the addition on this score would be $60 \times 15 \times 2 = 1800$d. = £7 10s.

The method, though convenient, is, however, far from accurate, and cannot be recommended to the manufacturer who desires to perform his calculations in a reliable manner.

Almost every manufacturer has an independent method of working out these calculations of total cost, and each believes his system the only reliable one. As a matter of fact the method of calculation is immaterial so long as the object in view is attained, namely, to make a profit and be able to compete in the market.

Considerable divergence is found in the method of estimating the weight of raw material used in producing a given fabric. One maker will simply multiply together the number of warp ends, length of each, and count of yarn, and add a percentage for waste. To obtain accurate results by this method it is necessary to first ascertain the exact count of the yarn from a hank before beaming.

Another will weigh the warp as it comes from the beaming machine, in which case the weight of the beam must be known and deducted as tare. If more than one beam is used, all should be numbered and their tare booked.

A third will weigh the warp after it has been sized and dried, an allowance of 3-4 per cent. being deducted for the size.

A fourth weighs the woven and dried piece, in which case 4-5 per cent. is allowed for waste and 3-4 per cent. for size.

A fifth weighs the finished cloth, and must of course be acquainted with the contraction in weaving and finishing. This is the least reliable method of all, the best being the second, namely, weighing the beamed warp and allowing a small percentage for waste and thrums. As a rule, for the sake of convenience, the first method is chosen, the weight being reckoned by multiplying the length of the warp by the yarn number. This leads to frequent errors, owing to the irregularity in yarns supposed to be of the same number and to unequal tension in beaming, the result being that the measured length is greater or less than the truth.

In the present depressed state of the textile industry when one has to reckon in fractions of a penny, great care throughout the working of calculations is essential. True, if the first method be adopted, one has merely to accurately ascertain the yarn number by examining a few hanks of the yarn and taking the average, since three or four different thicknesses are often supplied by the spinner as one and the same count. When the weft is of the same count or price as the warp yarn, the method No. 4 may be used, an allowance being deducted for the size or dressing, and an addition made for the waste in weaving.

In the fifth method an error may easily occur in connection with the percentage to be allowed for in respect of loss in scouring, milling, raising and shearing.

According as a greater or smaller addition of shoddy is employed in woollen fabrics, so will the shrinkage vary in the finishing process. To determine the amount in each case is an easy matter by weighing the pieces before and after finishing and comparing the results.

Variations from the normal will, nevertheless, continue to occur, according as one or other of the pieces has been differently treated in the milling process (kept too dry), or carded too vigorously in raising.

In the following lines the first-named method of calculation has been adopted for determining the weight of the warps.

So far as concerns the length of the goods there are three different lengths in question :—

(1) The length of the beamed warp which applies to the warp yarn only.

(2) The length of the web as it issues from the loom, this being a criterion of the weft yarn exclusively.

(3) The length of the finished piece which is then employed as a divisor for ascertaining the cost of finishing and dyeing, as also the price per yard.

As the unit of warp length we will take 100 yds., since this will give enough for 2 pieces of cloth. It has already been repeatedly stated that the warp contraction in the loom is influenced by so many factors as to absolutely preclude the establishment of a fixed standard; consequently the manufacturer must ascertain the percentage of contraction in the loom and in finishing separately for each class of fabric, if his calculations are to lay any claim to accuracy.

Furthermore, the calculation will have to be modified according as the work is of a simple or complex character. Thus, if we have to deal with the purchase of wool, scouring, spinning, weaving, finishing and dyeing, we might extend the calculation over the whole; but as this would unnecessarily complicate matters, it is preferable to book each operation to a separate

account, the more so as this method affords a more reliable control. Let us take, for example, the spinning account.

Here we have first to do with the wool itself, then the outlay for sorting, cleaning, opening, carding and spinning; next the supervising staff, then the total amount of wool-softening and lubricating oil, card furniture, coal for fuel and heating, taxes, fire and other insurances, sick fund, etc., etc., and determine at the year's end how much yarn has been worked up. In the same manner, separate accounts may be kept for warp beaming, sizing and drying, weaving, nopping and repairing, washing, milling, raising, drying, shearing, pressing and steaming, carbonising and dyeing.

If, at the end of the year, it is found that one or other operation is attended with too much expense, one knows at least where alteration is necessary, whereas if the whole be booked together it is a difficult matter to say where any economy can be effected.

By proceeding on the same lines it is easy to find the outlay on labour and the sundries appertaining thereto, also the general expenses, etc., so that the actual work of calculation can be based on reliable data.

In the following examples we will first consider several instances where all the operations, except carbonising and dyeing are carried out on the premises, and these will be succeeded by others wherein everything except nopping and stopping is done by contract.

SECTION III. (*Continued*).

CHAPTER III.

EXAMPLES OF SEVERAL METHODS OF CALCULATING.

Example 1.—This calculation relates to a good quality, 2-shaft piece-dyed woollen fabric, or ordinary cloth weave on the subjoined data :—

Weave, plain (Fig. 24).

Number of warp ends, 2800.

Number of selvage ends, 16 × 2 = 32 in all.

Width of unfinished cloth, 80 ins. between selvages.

Reed, 17½ two-end dents per inch.

Warp length, 100 yds. for 2 pieces of cloth.

Number of picks, 47½ per inch.

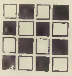

Fig. 24.

Warp yarn, No. 13, at 2s. 4d. per lb.

Weft yarn, No. 13, at 2s. 1d. per lb.

Weft contraction in the loom, 5 per cent.

Woollen selvage yarn, No. 11/2's, 11d. per lb.

Total loss of material in beaming and weaving, 4 per cent.

Longitudinal shrinkage in weaving, 8 per cent.

Shrinkage in washing and milling, 20 per cent. of the unfinished cloth.

Loss of weight in finishing, 22 per cent.

Cash outlay for beaming, sizing and drying, $\frac{1}{16}$d. per 1000 yds.

Add 120 per cent. for salaries, repairs and wear of machinery, rent, size, steam and power.

Cost of tying up, including wear and tear of harness, $\frac{5}{8}$d. per 100 ends.

Weaving, 1¼d. for simple cloth.

Add 50 per cent. for salaries of manager, designer, foremen, etc., repairs, machine parts, rent, light and power.

Cost of nopping and mending the two pieces, 5s.

Add $33\frac{1}{3}$ per cent. for foreman, examiner, fire, sewing silk, etc.

Cost of finishing, $3\frac{1}{4}$d. per yard.

Add 50 per cent. for steam, water, soda, soap, raising cards, etc.

Cost of carbonising, neutralising and rinsing, 7s. for the two pieces.

Cost of dyeing, $1\frac{7}{8}$d. per lb.

Other additions are :—

For delayed payment by customers, 2 per cent.

For agents and commission only 1 per cent., the goods being ordinary current wares.

Samples, 1 per cent.

Interest on cost of material during manufacture, 2 per cent.

For sudden increase of price in raw material, 2 per cent.

For defective pieces, $\frac{1}{8}$ per cent.

For over measure, $\frac{1}{2}$ per cent.

For banker's discount and charges, loss in exchange, fire and other insurances, sick fund, general and petty expenses, 5 per cent.

Freight and packing, 1 per cent.

For profit 6 per cent. only, the goods being of ordinary quality.

For discount to customers, 6 per cent.

In this example we have 2800 warp ends of 100 yds., or a total length of 280,000 yds. of warp.

The yarn being No. 13 count, the total weight will be $280{,}000 \div (560 \times 13) = 38\frac{1}{2}$ lb., and, as the price is 2s. 4d. per lb., the total cost will be $38\frac{1}{2} \times$ 2s. 4d. = £4 9s.

The selvage threads are 32 in number, and as for this class of fabric they must be cut somewhat longer than the warp, we will allow a margin of 2 yds. on each, so that the total length required will be $32 \times 102 = 3264$ yds. This yarn being No. 11/2's or $5\frac{1}{2}$ singles, the weight required will be $3264 \div (560 \times 5\frac{1}{2}) = 1\frac{1}{16}$ lb., which, at the rate of 11d. per lb., amounts to $11\frac{1}{2}$d. for the two pieces. The cloth is to contain $47\frac{1}{2}$ picks per inch, but, as the warp contraction in the loom amounts to 8 per cent., the net length issuing from the loom will be only 92 yds., so that the total number of picks inserted will be $47\frac{1}{2} \times 36 \times 92 = 157{,}320$.

The cloth is 80 ins. between selvages in the loom, or 81 ins. in all; consequently the 157,320 picks will have a total length of 353,970 yds. The yarn being No. 13, the weight of these 353,970 yds. will be 353,970 ÷ (560 × 13) = 48$\frac{5}{8}$ lb., which, at 2s. 1d. per lb., amounts to £5 1s. 3d.

The cash expenditure on beaming, sizing and drying is $\frac{1}{16}$d. per 1000 yds. of warp, so that the cost of beaming, etc., our 280,000 yds. of warp will be 1s. 6d. To this must be added 120 per cent. for sundries, *i.e.*, 1s. 9d.

Tying up costs $\frac{5}{8}$d. per 100 ends, or 1s. 6d. for the whole 2800 ends.

The cash outlay for weaving this class of goods is 1$\frac{1}{4}$d. per 1000 picks, or a total of 16s. 4d. for the 157,320 picks. This sum, as already mentioned, must be augmented by 50 per cent., or 8s. 2d.

For nopping and mending we can only in this case count 5s. for the two pieces, with an addition of 40 per cent., or 2s., for the overlooker, etc.

Finishing costs 3$\frac{3}{8}$d. per yd. for finished cloth, which, allowing 20 per cent. for shrinkage in washing and milling, will be 73·6 yds., the cost working out to £1 0s. 9d. This in turn must be augmented by 50 per cent. for sundries, namely, 10s. 4$\frac{1}{2}$d.

Carbonising, neutralising and rinsing cost 7s. for the two pieces.

Black dyeing, according to the price quoted above, costs 1$\frac{7}{8}$d. per lb. It, therefore, remains to ascertain the weight of the finished cloth.

Now the warp yarn weighs	38$\frac{1}{2}$ lb.
,, weft ,, ...	48$\frac{5}{8}$ lb.
and the selvage ,, ...	1$\frac{1}{16}$ lb.
Together . .	88$\frac{3}{16}$ lb.

Since the goods lose 22 per cent. in washing and milling, the loss will amount to (22 × 88$\frac{3}{16}$) ÷ 100 = 19$\frac{7}{16}$ lb., which will leave 68$\frac{3}{4}$ lb. as the net weight. The cost of dyeing will, therefore, be 68$\frac{3}{4}$ × 1$\frac{7}{8}$ = 10s. 9d.

Our calculation may now be tabulated as follows :—

	£	s.	d.
Cost of warp yarn	4	9	0
Allowance for loss, 4 per cent. . .	0	3	6
Cost of weft	5	1	3
Loss, 4 per cent.	0	4	0
Cost of selvage yarn	0	0	11½
Cost of beaming	0	1	6
Add for sundries, 120 per cent. . .	0	1	9
Tying up	0	1	6
Cost of weaving	0	16	4
Add for sundries, 50 per cent. . . .	0	8	2
Nopping and mending	0	5	0
Add for sundries, 40 per cent. . . .	0	2	0
Finishing	1	0	9
Add for sundries, 50 per cent. . . .	0	10	4½
Carbonising, etc.	0	7	0
Dyeing	0	10	9
Total . . .	14	3	10
We have further to add :—			
For delays in settlement, 2 per cent. .	0	5	8
Agents and commission, 1 per cent. . .	0	2	10
Cost of samples, ⅛ per cent. . . .	0	0	4
Loss of interest on material during manufacture, 2 per cent.	0	5	8
Provision for sudden rise in materials, 2 per cent.	0	5	8
Provision for defective pieces, ⅛ per cent. .	0	0	4
Provision for over measure, ½ per cent. .	0	1	5
Banker's discount, charges, etc., 5 per cent.	0	14	3
Freight and packing, 1 per cent. . .	0	1	5
Profit, 6 per cent.	0	17	0
Total . . .	16	18	5

Now the purchaser as a rule demands 6 per cent. discount. Some manufacturers reckon this percentage on the material, labour and sundries, in this case £14 3s. 10d. ; but this system is erroneous, the 6 per cent. being deducted from the full

amount of the invoice and not from merely a portion of same. If we reckon the 6 per cent. on the total figure obtained above, *viz.*, £16 18s. 5d., we get £1 0s. 5d., which makes up the grand total to £17 18s. 10d. This sum divided among 73·6 yds., the net measurement of the two pieces, works out to 4s. 10½d. per yd. We can, therefore, sell the cloth at 4s. 10½d. per yd., less 6 per cent. discount.

If the details of this calculation be set out in accordance with the second system referred to above, we have the following tabular statement:—

	£	s.	d.
Cost of warp yarn	4	9	0
Allowance for loss	0	3	6
Cost of weft	5	1	3
Allowance for loss	0	4	0
Cost of selvage yarn	0	0	11½
Cash outlay for beaming, sizing, etc.	0	1	6
,, ,, tying up	0	1	6
,, ,, weaving	0	16	4
,, ,, nopping and mending	0	5	0
,, ,, finishing	1	0	9
,, ,, carbonising, etc.	0	7	0
,, ,, dyeing	0	10	9
Total cash outlay	13	1	6½
For the additions we have:—			
For beaming, sizing, etc.	0	1	9
,, weaving	0	8	2
,, nopping, etc.	0	2	0
,, finishing	0	10	4½
Apart from profit and discount, the other additions amount to 13¾ per cent., or	1	17	7
	2	19	10½
The cash outlay amounts to	13	1	6½
,, additions to	2	19	10½
,, profit to	0	17	0
,, discount to	1	0	5
Total	17	18	10

Hence, apart from direct cash outlay, we have to reckon :—

	£	s.	d.
For additions	£2	19	10½
,, profit	0	17	0
,, discount	1	0	5
Together	£4	17	3½

Some few manufacturers reckon only the percentage additions according to the second method, whilst others calculate these additions with the profit and discount, and extract a certain percentage as the total addition to the cost. If we take this latter method, the position is stated in the following manner :—

Assuming that £13 1s. 6½d. has to be augmented by £4 17s. 3½d. for additions, profit and discount, then £1 will require an addition of £4 17s. 3½d. × 100 ÷ £13 1s. 6½d. = 37·2 per cent.

Hence, in calculating by the second method, the cost of material and cash outlay for labour would have to be augmented by 37·2 per cent., including profit and discount.

Mention has been made of a third method of calculation, wherein the cost of materials and labour being determined, the additions, profit and discount are worked out at so much per yard. This is effected in the following manner, taking the above data as a basis :—

In addition to the direct expenditure we have the sum of £4 17s. 3½d. for extras, profit and discount on the two pieces, together measuring 73·6 yds. This is at the rate of 1s. 4d. per yd., which would have to be added to the cost of materials and labour in calculating by the third method.

The fourth method, already alluded to, will be disregarded as too simple and unreliable.

Example 2.—Calculating a high-class piece-dyed wool satin (weave shown in Fig. 25), from the following data :—

Number of warp ends, 7200.

Breadth in loom, 72 ins. between selvages.

Reed, 20 five-end dents per inch.

Number of selvage threads, 20 × 2 = 40 ends.

Number of picks per inch, 56.

Warp woollen yarn, No. 18½, at 2s. 4d. per lb.

Weft woollen yarn, No. 16, at 2s. 3d. per lb.

Selvage yarn, No. 11/2's, at 11d. per lb.

Weft contraction in the loom, 5 per cent.

Loss of warp and weft in beaming and weaving respectively, 5 per cent.

Warp contraction in the loom, 6 per cent.

Shrinkage in washing and milling, 12 per cent. of the web.

Loss of weight in finishing, 20 per cent.

Cash outlay for labour in beaming, sizing, drying, etc., $\frac{1}{16}$d. per 1000 yards of yarn.

Add for overlooker, size, steam power, rent, etc., 120 per cent.

Tying up, $\frac{5}{8}$d. per 100 ends.

Weaving, $1\frac{3}{8}$d. per 1000 picks.

Add for salaries, machine parts, repairs, light, fire, etc., $66\frac{2}{3}$ per cent.

Nopping and mending, 8s. for the two pieces.

Add for overlooker, examiner, light, etc., 40 per cent.

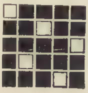

FIG. 25.

Finishing, $3\frac{3}{8}$d. per yard finished cloth.

Add for salary, power, steam, water, soap, soda, card furniture, etc., 50 per cent.

Carbonising, neutralising and rinsing, 7s. for two pieces.

Dyeing, $1\frac{7}{8}$d. per lb.

Special contingencies :—

For delay in payment, 2 per cent.

Agents and commission, 1 per cent.

Samples, $\frac{1}{2}$ per cent.

Loss of interest on cost of material during manufacture, 2 per cent.

Eventual sudden rise in cost of materials, 2 per cent.

Defective pieces, $\frac{1}{2}$ per cent.

Over measure, $\frac{1}{2}$ per cent.

Banker's discount and charges, loss in exchange, fire and other insurances, sick fund, general and petty expenses, 5 per cent.

Freight and packing, 1 per cent.

Profit, 7 per cent.

Discount to customers, 6 per cent.

In the warp we have 7200 ends, each of 100 yds., or a total of 720,000 yds. The yarn is No. $18\frac{1}{2}$ or 10,360 yds. per lb., so that 720,000 yds. will weigh $69\frac{1}{2}$ lb., which at 2s. 4d. per lb. will cost £8 2s. 2d.

The selvage threads are $20 \times 2 = 40$ in number, and as each measures 102 yds., the whole will measure $102 \times 40 = 4080$ yds. The yarn is No. 11/2's or No. $5\frac{1}{2}$ singles, running 3080 yds. to the lb., so that the 4080 yds. weigh $1\frac{5}{16}$ lb. and cost at 11d. per lb. 1s. 2d. The weaver has to insert 56 picks per inch or 2016 per yard, and as the contraction in the loom is 6 per cent., the net length of the web will be 94 yds., which will therefore contain 189,504 picks.

Each pick measures 72 ins. + 2 ins. for selvage, together 74 ins., so that the 189,504 picks will consume $\frac{74 \times 189504}{36}$ $= 389536$ yds. The weft contraction being 5 per cent. in the loom, the above amount will be only 95 per cent. of the required amount of weft yarn which will therefore be $\frac{389536 \times 100}{95} = 410037$ yds.

As mentioned above, the weft yarn is No. 16 and therefore runs 8960 yds. to the lb.; consequently the 410,037 yds. weigh $45\frac{3}{4}$ lbs., and cost, at 2s. 3d. per lb., $45\frac{3}{4} \times$ 2s. 3d. = £5 1s. 4d.

The cash expended on labour for beaming, sizing, drying, etc., is $\frac{1}{16}$d. per 1000 yds. of warp yarn, which for the 720,000 yds. of warp make 3s. 9d. Tying up costs $\frac{5}{8}$d. per 100 ends, or for the 7200 ends 3s. 9d.

Weaving this fabric costs at the rate of $1\frac{3}{8}$d. per 1000 picks, which for the 189,504 picks in question amounts to £1 1s. 9d.

For nopping and mending we calculated on 8s. for the two pieces. Finishing costs $3\frac{3}{8}$d. per yd. final measurement and since the web measures 94 yds. and loses 12 per cent. in washing and milling, the net length of the cloth is $82\frac{3}{4}$ yds., the cost of finishing which is £1 3s. 4d.

For carbonising, neutralising and rinsing the outlay on the two pieces is 7s.

Dyeing in this case costs $1\frac{7}{8}$d. per lb.

Weight of warp yarn	$69\frac{1}{2}$ lb.
,, selvages . . .	$1\frac{5}{16}$,,
,, weft . . .	$45\frac{3}{4}$,,
	$116\frac{9}{16}$ lb.

The loss in weight, however, during washing, milling and finishing is 20 per cent., or on $116\frac{9}{16}$ lb. $= \dfrac{20 \times 116\frac{9}{16}}{100} = 23\frac{5}{16}$ lb., which leaves a net weight of $116\frac{9}{16} - 23\frac{5}{16} = 93\frac{1}{4}$ lb. At $1\frac{7}{8}$d. per lb. this gives 14s. 8d.

The calculations may be tabulated as under :—

	£	s.	d.
Cost of warp	8	2	2
Loss in beaming and weaving, 4 per cent.	0	6	6
Cost of selvage yarn	0	1	2
Cost of weft yarn	5	1	4
Weft contraction in the loom, 4 per cent.	0	4	0
Paid out for beaming, sizing, etc. . .	0	3	9
Add 120 per cent.	0	4	7
Tying up	0	3	9
Weaving	1	1	9
Add $66\frac{2}{3}$ per cent.	0	14	6
Nopping and mending	0	8	0
Add 40 per cent.	0	3	3
Finishing	1	3	4
Add 50 per cent.	0	11	8
Carbonising, etc.	0	7	0
Dyeing	0	14	8
Total cash outlay for material, labour, etc.	19	11	5
Including profit but not discount, this has to be augmented by $20\frac{7}{8}$ per cent. .	4	1	7
Together	23	13	0
On adding 6 per cent. for discount we obtain	1	8	4
	£25	1	4

Thus our $82\frac{3}{4}$ yds. of finished cloth can be sold at £25 1s. 4d. ÷ $82\frac{3}{4}$ = 6s. 1d. per yd., less 6 per cent. discount.

In this case, and in those following, the second and third systems of calculating will be omitted.

EXAMPLE 3.—Calculation of an ordinary Eskimo fabric (weave shown in Fig. 26) from the subjoined data:—

Number of warp ends, 4500.

Breadth of web between selvages, 80 ins.

Reed, $18\frac{3}{4}$ three-ends dents per inch.

Number of selvage threads, 2 × 20 = 40.

Length of warp, 100 yds. for two pieces of cloth.

Weft count, $82\frac{1}{2}$ picks per inch (55 face and $27\frac{1}{2}$ back weft).

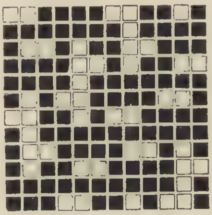

FIG. 26.

Warp yarn, No. $14\frac{1}{2}$, at 2s. 2d. per lb.

Face weft, No. 14, ,, 1s. 9d. ,,

Back weft, No. 4, ,, 6d. ,,

Weft ratio, 2 picks of face to 1 of back.

Selvage yarn, No. 11/2's, at 11d. per lb.

Weft contraction in the loom, 5 per cent.

Loss of warp and face weft in beaming and weaving respectively, 4 per cent.

Loss of back weft in weaving, 6 per cent.

Warp contraction in the loom, 7 per cent.

Shrinkage in milling and finishing, 14 per cent.

Loss of weight in finishing, 28 per cent.

Cost of sizing, beaming, drying, $\frac{1}{10}$d. per 1000 yds.

Add 120 per cent. (See Example 1.)

Tying up, $\frac{5}{8}$d. per 100 ends.

Cost of weaving, $1\frac{5}{8}$d. per 1000 picks.

Add $66\frac{2}{3}$ per cent. (See Example 1.)

Nopping and mending, 10s. for the two pieces.

Add 40 per cent. (See Example 1.)

Finishing, $3\frac{1}{2}$d. per yd. of net measurement.

Add 50 per cent. (See Example 1.)

Carbonising, neutralising and rinsing, 7s. per two pieces.

Dyeing, $1\frac{7}{8}$d. per lb. final weight.

To these come the other additions specified in Example 2.

The warp containing 4500 ends of 100 yds. each, the total length of warp yarn will be 450,000 yds. Since the yarn is No. $14\frac{1}{2}$, running 8120 yds. to the lb., the total weight required will be $450000 \div 8120 = 55\frac{1}{2}$ lb., and the cost at 2s. 2d. per lb. = £6 0s. 3d.

The number of picks per inch is $82\frac{1}{2}$, of which 55 are face weft and $27\frac{1}{2}$ back weft. The number of face picks per yd. will, therefore, be $55 \times 36 = 1980$.

Since the warp contracts by 7 per cent. in weaving, the web will only measure 93 yds., and, consequently, the total number of face picks for that length will be $1980 \times 93 = 184140$. The length of each pick is 80 ins. + 2 ins. for selvages = 82 ins., and, therefore, the 184,140 picks will measure 419,430 yds. However, since the weft contracts 5 per cent. in weaving, this quantity is only 95 per cent. of the total, which will, therefore, be $\frac{419430 \times 100}{95} = 441505$ yds.

The face weft is No. 14 yarn, running 7840 yds. to the lb., so that 441,505 yds. will weigh $58\frac{3}{4}$ lb., which, at 1s. 9d. per lb., will cost £5 2s. 10d.

Since there are 2 face picks to each back pick, the latter will only require half the length of the yarn consumed by the former, or 220,752 yds. The yarn being No. 4 has 2240 yds. to the lb., and the weight required is, therefore, $98\frac{1}{2}$ lb., which, at 6d. per lb., will cost £2 9s. 3d.

The cost of selvage yarn is the same as in the preceding example, *viz.*, 1s. 2d.

The cost of sizing, drying and beaming is $\frac{1}{16}$d. per 1000 yds. of warp, *i.e.*, 442 × $\frac{1}{16}$d. = 2s. 4d.

Tying up costs $\frac{5}{8}$d. per 100 warp ends, so that the 4500 ends will cost on this account 45 × $\frac{5}{8}$d. = 2s. 4d.

The price paid for weaving is 1$\frac{5}{8}$d. per 100 picks; consequently the 184,140 face picks and 92,070 back picks = 276,210 together will cost 276·2 × 1$\frac{5}{8}$d. = £1 17s. 5d.

Nopping and mending cost 10s. per two pieces.

Finishing costs 3½d. per yd. of finished length. The web measuring 93 yds., the allowance of 14 per cent. for shrinkage and milling and finishing reduces the length to 80 yds. = £1 3s. 4d.

Carbonising, etc. = 7s. per two pieces.

Dyeing costs 1$\frac{7}{8}$d. per lb. of final weight.

The warp weighs	55½ lb.
,, face weft weighs	58¾ ,,
,, back ,, ,, ...	98½ ,,
,, selvage ,, ...	1$\frac{5}{16}$,,
Together	214$\frac{1}{16}$ lb.

The allowance for loss of weight in milling is 28 per cent., so that the net weight will be 154 lb. The cost of dyeing will, therefore, be 154 × 1$\frac{7}{8}$d. = £1 4s. 2d.

Tabulated, the calculation is as follows:—

	£	s.	d.
Cost of warp yarn	6	0	3
Loss, 4 per cent.	0	4	10
Cost of face weft	5	2	10
Loss, 4 per cent.	0	4	2
Cost of back weft	2	9	3
Loss, 6 per cent.	0	3	0
Cost of selvage	0	1	2
,, sizing and beaming . . .	0	2	4
Add 120 per cent.	0	2	10
Tying up	0	2	4
Weaving	1	17	5
Carried forward . .	16	10	5

	£	s.	d.
Brought forward . .	16	10	5
Add $66\frac{2}{3}$ per cent.	1	5	0
Nopping and mending	0	10	0
Add 40 per cent.	0	4	0
Finishing	1	3	4
Add 50 per cent.	0	11	8
Carbonising, etc.	0	7	0
Dyeing	1	4	2
Cost of material, labour and additions .	21	15	7
To this must be added, including profit but not discount, $19\frac{7}{8}$ per cent .	4	6	5
Together . . .	26	2	0
On adding 6 per cent. for discount .	1	11	4
The total price is	27	13	4

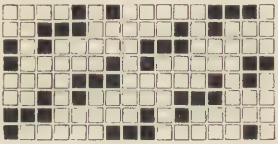

FIG. 27.

Since the cloth measures 80 yds., the selling price per yd. works out at £27 13s. 4d. ÷ 80 = 6s. 11d. per yd., less 6 per cent. discount.

EXAMPLE 4.—Calculation of a rough Cheviot with woollen back warp (weave, see Fig. 27) from the following data :—

Number of face warp ends of Cheviot yarn, 2970.

Number of back warp ends of woollen yarn, 2970.

Width in loom between selvages, 72 ins.

Reed, $13\frac{3}{4}$ six-end dents per inch.

Length of warp, 100 yds. for two pieces.

Selvage threads, 2 × 50 Cheviot = 100.

Number of picks per inch, 50.
Count of face warp, No. 39/2's, at 1s. 10d. per lb.
Count of back warp, No. 21/2's, at 1s. per lb.
Weft Cheviot, No. 39/2's, at 1s. 9d. per lb.
Contraction in loom, 8 per cent.
Loss on Cheviot yarn in beaming and weaving, 4 per cent.
Loss on woollen yarn in beaming and weaving, 5 per cent.
Shrinkage in milling, 8 per cent. of web dimensions.
Loss of weight milling, 15 per cent.
Beaming and sizing, $\frac{1}{16}$d. per 100 ends.
Tying up, $\frac{3}{4}$d. per 100 ends.
Weaving, $1\frac{1}{2}$d. per 1000 picks.
Nopping and mending, 7s. for the two pieces.
Finishing, $2\frac{1}{4}$d. per yard.
Carbonising, etc., 7s. for two pieces.
Dyeing, $2\frac{1}{4}$d. per lb. net weight.
The other additions include :—
For delayed payments by customers, 2 per cent.
Agents and commission, 2 per cent.
Samples, 1 per cent.
Loss of interest on material during manufacture, 2 per cent.
Margin for rise of material in price, 2 per cent.
Margin for defective pieces, $\frac{1}{4}$ per cent.
Margin for over measure, $\frac{1}{2}$ per cent.

Banker's discount and charges, loss in exchange, fire and other insurances, sick fund, general and petty expenses, 5 per cent.

Freight and packing, 1 per cent.
Profit, 7 per cent.
Discount to customers, 6 per cent.

There are 2970 ends of face or Cheviot warps, and 100 of similar material for the selvages, *i.e.*, 3070 ends together, each 100 yds. long or 307,000 yds. of face warp. The yarn is No. 39/2's = No. $19\frac{1}{2}$ singles, which at 10,920 yds. to the lb. gives a weight of $28\frac{1}{4}$ lb. The cost at 1s. 10d. per lb. is therefore £2 11s. 9d.

In the back warp are 2970 ends of 100 yds. or 297,000 yds.

The yarn being No. 21/2's or $11\frac{1}{2}$ singles goes 6440 yds. to the lb., and the 297,000 yds. weigh 46 lb., which at 1s. per lb. gives 46s. as the cost of the back warp.

The weft count is 50 picks per inch, and since the web is 92 per cent. of the warp length (the contraction being 8 per cent), there will be in the 92 yds. of cloth $50 \times 36 \times 92 = 165600$ picks.

The width of the cloth in the loom is 72 ins. + 2 ins. (selvage) = 74 ins., and hence the length of weft yarn will be 165600×74 ins. = 340400 yds.; but as the weft contraction in the loom is 5 per cent. the total length of weft required will be $\frac{340400 \times 100}{95} = 358315$ yds.

This yarn is No. 39/2's = $19\frac{1}{2}$ singles, running 10920 yds. per lb., and therefore 358,315 yds. weigh 33 lb., which at 1s. 9d. per lb. gives £2 17s. 9d. as the cost of the weft.

Sizing, drying and beaming cost $\frac{1}{16}$d. per 1000 yds. of warp yarn, *i.e.*, $307000 + 297000 = \frac{604000 \times \frac{1}{16}}{1000} = 3s.\ 2d.$

Tying up costs $\frac{3}{4}$d. per 100 ends, there being two kinds of warp, hence the 6040 ends cost 3s. 9d.

Weaving costs $1\frac{1}{2}$d. per 1000 picks, or for 165600 picks £1 0s. 9d.

For nopping and mending the two pieces the cost is 7s.

Finishing is $2\frac{1}{4}$d. per yard of finished cloth. The web shrinks 8 per cent. in milling, and therefore the 92 yds. are reduced to $84\frac{5}{8}$ yds. = 15s. 10d.

The cost of carbonising, etc., is 7s. the two pieces.

Dyeing costs $2\frac{1}{4}$d. per lb. of net weight.

Now, the Cheviot warp weighs . . .	$28\frac{1}{4}$ lb.
,, back ,, ,, . . .	46 ,,
,, weft ,, ,, . . .	33 ,,
	$107\frac{1}{4}$ lbs.

But as the goods lose 15 per cent. in washing and milling, the net weight is reduced to 91 lb., which at $2\frac{1}{4}$d. per lb. gives 17s. 1d. as the cost of dyeing.

The calculation may therefore be grouped as follows :—

	£	s.	d.
Cost of Cheviot warp yarn	2	11	9
Loss, 3 per cent.	0	1	6
Back warp	2	6	0
Loss, 4 per cent.	0	1	10
Cheviot weft yarn	2	17	9
Loss, 3 per cent.	0	1	10
Beaming, sizing, etc.	0	3	2
Add 120 per cent.	0	3	9
Tying up	0	3	9
Weaving	1	0	9
Add $66\frac{2}{3}$ per cent.	0	13	10
Nopping and mending	0	7	0
Finishing	0	15	10
Add 50 per cent.	0	7	11
Carbonising, etc.	0	7	0
Dyeing	0	17	1
	13	0	9
To this must be added $22\frac{3}{4}$ per cent. including profit but not discount .	2	19	4
Together	16	0	1
6 per cent. discount = ...	0	19	3
Total	16	19	4

The length of the cloth being $84\frac{5}{8}$ yds., the goods may therefore be sold at £16 19s. 4d. ÷ $84\frac{5}{8}$ = 4s. $0\frac{1}{4}$d. per yard with 6 per cent. discount.

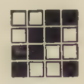

FIG. 28.

EXAMPLE 5.—Calculation of a cheap, single, light, wool-dyed Cheviot fabric (weave Fig. 28) from the following data :—

Number of warp ends, 2160.

Width in loom, 72 ins. between selvages.

Reed, $7\frac{1}{2}$ four-end dents per inch.

Warp, 100 yds. long for two pieces.

Number of selvage threads, $30 \times 2 = 60$; Cheviot yarn same as warp.

Number of picks per inch, $37\frac{1}{2}$.

Count of warp and weft yarns, No. 14/2's, at 1s. $4\frac{1}{2}$d. per lb.

Warp contraction in loom, 7 per cent.

Weft ,, ,, 5 ,,

Loss in beaming and weaving, 4 per cent.

Shrinkage of web in milling, etc., 8 per cent.

Loss of weight ,, ,, 14 ,,

Cost of sizing, beaming, etc., $\frac{1}{16}$d. per 1000 yds.

Tying up, $\frac{5}{8}$d. per 100 ends.

Weaving, $1\frac{5}{16}$d. per 1000 picks.

Nopping and mending, 5s. the two pieces.

Finishing, $1\frac{3}{4}$d. per yd. of finished cloth.

Sundries :—

For delays in payment, 2 per cent.

Agents and commission, 2 per cent.

Samples, $\frac{1}{2}$ per cent.

Loss of interest on material during manufacture, 2 per cent.

For sudden rise in raw material, 2 per cent.

,, defective pieces, $\frac{1}{4}$ per cent.

,, over measure, $\frac{1}{2}$ per cent.

Banker's discount and charges, loss in exchange, fire and other insurances, sick fund, general and petty expenses, 5 per cent.

Freight and packing, 1 per cent.

Profit, 6 per cent.

Discount, 6 per cent.

There are 2160 warp ends and 60 selvage threads of the same material, together 2220 ends of Cheviot yarn of 100 yds. each, or 222,000 yds. of warp in all.

The yarn is No. 14/2's = 7 singles, at 3920 yds. per lb.,

and the 222,000 yds., therefore, weigh $56\frac{3}{4}$ lb., which, at 1s. $4\frac{1}{2}$d. per lb., gives the cost = £3 19s.

The number of picks is $37\frac{1}{2}$ per inch, or 1350 per yd. Since the warp contracts 7 per cent. in the loom, the length of the web will be 93 yds., which will give a total of $1350 \times 93 = 125{,}550$ picks.

The length of each pick is 72 ins. + 2 ins. (selvages) = 74 ins., so that the length of the weft yarn is $125{,}550 \times 74$ ins. = 258,075 yds. As the weft contraction is 5 per cent., this length is only 95 per cent. of the total required, *i.e.*, $\frac{258075 \times 100}{95} = 271657$ yds.

The weft yarn is No. 14/2's = No. 7 singles, and as 3920 yds. go to the lb., the weight will be $271657 \div 3920 = 69\frac{1}{3}$ lb., which, at 1s. $4\frac{1}{2}$d. per lb. = £4 15s. 9d.

Sizing, beaming, etc., cost $\frac{1}{16}$d. per 1000 yds. of warp, or $222 \times \frac{1}{16}$d. = 1s. 2d.

Tying up is $\frac{5}{8}$d. per 100 ends = 1s. 2d.

Weaving costs $1\frac{5}{16}$d. per 1000 picks, and as there are 125,550 picks, this item amounts to 13s. 9d.

Nopping and mending = 5s. the two pieces.

Finishing in this case is only $1\frac{3}{4}$d. per yd. of net measurement. The goods shrink 8 per cent. in milling, etc., so the 93 yds. of web will lose $\frac{93 \times 8}{100} = 7\frac{1}{2}$ yds., leaving $85\frac{1}{2}$ yds. net. This at the rate quoted = 12s. 6d.

Tabulated, the calculation reads :—

	£	s.	d.
Cost of warp and selvage yarn . . .	3	19	0
Loss, 4 per cent.	0	3	2
Weft yarn	4	15	9
Loss, 4 per cent.	0	3	10
Sizing, beaming, etc.	0	1	2
Add 120 per cent.	0	1	5
Tying up the warp	0	1	2
Weaving	0	13	9
Add $66\frac{2}{3}$ per cent.	0	9	2
Nopping and mending	0	5	0
Add 40 per cent.	0	2	0
Finishing	0	12	6
Add 50 per cent.	0	6	3
Material, labour, etc. . . .	11	14	2
The sundry percentages amount to $21\frac{1}{4}$ per cent., including profit but not discount	2	9	10
Together . . .	14	4	0
Add discount, 6 per cent. . . .	0	17	0
Total	15	1	0

Since the finished cloth measures $85\frac{1}{2}$ yds., it may be sold at 3s. $6\frac{1}{4}$d. per yd., less 6 per cent. discount.

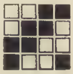

FIG. 29.

EXAMPLE 6.—Calculation of a simple, dark, milled, Cheviot mixture (weave Fig. 29) from the following specification :—

Number of warp ends, 3108.

Width in loom, 74 ins. between selvages.

Reed, $10\frac{1}{2}$ dents per inch.

Length of warp, 100 yards.

Number of selvage threads, $30 \times 2 = 60$ ends of Cheviot yarn

Number of picks per inch, 45.
Warp yarn, No. 21/2's, at 1s. $5\frac{1}{2}$d. per lb.
Weft yarn, No. 16/2's, at 1s. $5\frac{1}{2}$d. per lb.
Weft contraction in loom, 5 per cent.
Loss in beaming and weaving, 4 per cent.
Warp contraction in loom, 7 per cent.
Shrinkage in milling, 15 per cent.
Sizing and beaming, $\frac{1}{16}$d. per 1000 yds. of yarn.
Add 120 per cent.
Tying up, $\frac{5}{8}$d. per 100 ends.
Weaving, $1\frac{1}{4}$d. per 1000 picks.
Add $66\frac{2}{3}$ per cent.
Nopping and mending, 5s. the two pieces.
Add 40 per cent.
Finishing, $2\frac{3}{8}$d. per yd. of net length.
Add 50 per cent.
The other additions are the same as in Example 5.

There are 3108 warp ends and 60 selvage threads of the same yarn, together 3168 ends, measuring in all 316,800 yds. The yarn is No. 21/2's = $10\frac{1}{2}$ singles, running 6440 yds. per lb.; hence the weight is $49\frac{1}{4}$ lb. which at 1s. $5\frac{1}{2}$d. per lb. will cost £3 11s. 10d. The number of picks is 45 per inch or 1620 per yard. Since the warp contracts 7 per cent. in weaving, the 100 yds. will yield only 93 yds. of cloth, so that the total number of picks will be $1620 \times 93 = 150660$.

In the loom the cloth is 74 ins. + 2 ins. (selvages) = 76 ins. wide; consequently the 150,660 picks will give a length of 318,060 yds. of weft yarn. This, however, to allow for the 5 per cent. contraction in the loom, must be increased to

$$\frac{318060 \times 100}{95} = 334800 \text{ yds.}$$

The weft yarn is No. 16/2's = 8 singles going 4480 yds. to the lb., and therefore the weight is $334800 \div 4480 = 74\frac{3}{4}$ lb., which at 1s. $5\frac{1}{2}$d. per lb. = £5 9s.

Sizing and beaming cost $\frac{1}{16}$d. per 1000 yds. of warp, *i.e.*, $316{\cdot}8 \times \frac{1}{16}$d. = 1s. 8d.

Tying up = $\frac{5}{8}$d. per 100 ends, or $31{\cdot}68 \times \frac{5}{8}$d. = 1s. 8d.

Weaving costs $1\frac{1}{4}$d. per 1000 picks = 150·66 × $1\frac{1}{4}$d. = 15s. 8d.

Nopping and mending = 5s. the two pieces.

Finishing costs $2\frac{3}{8}$d. per yard of net measurement. Now the web is 93 yds. long, but is diminished 15 per cent. by shrinkage in milling, so that the loss is $\frac{15 \times 93}{100} = 14$ yds., and the net length 93 − 14 = 79 yds., which at $2\frac{3}{8}$d. = 15s. 8d.

On tabulating these results we have :—

	£	s.	d.
Cost of warp yarn	3	11	10
Loss, 4 per cent.	0	2	10
Weft yarn	5	9	0
Loss, 4 per cent.	0	4	4
Sizing, beaming, etc.	0	1	8
Add 120 per cent.	0	2	0
Tying up	0	1	8
Weaving	0	15	8
Add $66\frac{2}{3}$ per cent.	0	10	6
Nopping and mending	0	5	0
Add 40 per cent.	0	2	0
Finishing	0	15	8
Add 50 per cent.	0	7	10
Material, labour, etc.	12	10	0
Add, for sundries, including profit but not discount, $21\frac{1}{4}$ per cent.	2	13	2
Together	15	3	2
Discount, 6 per cent.	0	18	2
Total	16	1	4

Hence the 79 yds. of cloth can be sold at £16 1s. 4d ÷ 79 = 4s. $0\frac{1}{2}$d. per yard, less 6 per cent. discount.

SECTION III. (*Continued*).

CHAPTER IV.

EXAMPLES OF SEVERAL METHODS OF CALCULATING (*Contd.*).

EXAMPLE 7.—Calculation of a fine overcoating (Moutonné) pile cloth, wool-dyed (weave shown in Fig. 30) from the following data :—

Number of warp ends, 3426.
Web, 76 ins. wide between selvages.
Reed, $11\frac{1}{4}$ four-end dents per inch.
Length of warp, 100 yds. for two pieces.
Number of picks, 63 per inch.

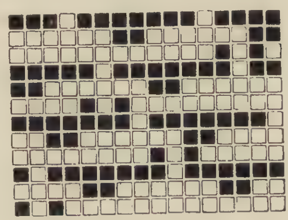

FIG. 30.

Face warp yarn, worsted Cheviot, No. $31\frac{1}{2}/2$'s, at 1s. 6d. per lb.
Back warp, woollen yarn No. $9\frac{1}{2}$, at 1s. $4\frac{1}{2}$d. per lb.
Warp setting, 1 end face, 1 of back.
Face or pile weft, No. $7\frac{1}{2}$, wound double, at 2s. 1d. per lb.
Ground weft, No. 8, at 1s. 10d. per lb.
Back weft, No. 6, at 1s. 10d. per lb.
Serial order of picks, 1 : 1 : 1.
Selvage yarn, same as face warp, 36 × 2 = 72 ends.

Weft contraction in the loom, 5 per cent.

Loss of face warp in beaming and weaving, 3 per cent.

Loss of back warp in beaming and weaving, 4 per cent.

Loss of total weft, 4 per cent.

Warp contraction in weaving, 7 per cent.

Shrinkage in milling, etc., 15 per cent.

Cost of sizing, beaming, etc., $\frac{1}{12}$d. per 1000 yds. of warp yarn.

Add 120 per cent.

Tying up 2 warps, $\frac{3}{4}$d. per 100 ends.

Weaving with 3 wefts, $1\frac{3}{4}$d. per 1000 picks.

Add, including extra cost of winding face weft double, 70 per cent.

Nopping and mending, 10s. the two pieces.

Finishing, $5\frac{7}{8}$d. per yard of net length.

Add 50 per cent.

The provision for other contingencies includes :—

For delays in payment, 2 per cent.

Agents and commissions, 2 per cent.

Loss of interest on material during manufacture, 2 per cent.

Sudden rise in raw material, 2 per cent.

Defective pieces, $\frac{1}{2}$ per cent.

Overmeasure, $\frac{1}{2}$ per cent.

Banker's discount and charges, loss in exchange, accident, fire and other insurances, sick fund, general and petty expenses, 5 per cent.

Profit, 9 per cent.

Discount, 6 per cent.

There are 1713 ends of face warp and 72 ends of selvage warp of the same material, each of 100 yds., the total length being, therefore, $(1713 + 72) \times 100 = 178{,}500$ yds. of worsted Cheviot.

The yarn is No. $31\frac{1}{2}/2$'s $= 15\frac{3}{4}$ singles, running 9380 yds. to the lb., and, therefore, weighing $178500 \div 9380 = 19$ lb., which, at 1s. 6d. per lb. = £1 8s. 6d.

In the back warp we have 1713 ends of 100 yds., or

171,300 yds. of No. $9\frac{1}{2}$ yarn, running 5320 yds. to the lb., and weighing $32\frac{1}{4}$ lb., which, at 1s. $4\frac{1}{2}$d. per lb. = £2 4s. 4d.

There are 63 picks per inch, distributed equally among the face, ground and back wefts, 21 of each per inch, or 756 per yd. Since the warp contraction is 7 per cent., the web will measure $100 - 7 = 93$ yds., and there will, therefore, be $93 \times 756 = 70308$ picks of each of the three wefts in the full length.

Each pick measures 76 ins. + 2 ins. (selvages) = 78 ins., and, therefore, the 70,308 picks of each weft will measure 70308×78 ins. = 152234 yds.; but since an allowance of 5 per cent. has to be made for weft contraction in the loom, the total length of yarn required for each weft will be $\frac{152234 \times 100}{95} = 160246$ yds.

The pile weft is No. $7\frac{1}{2}$ double, and may, therefore, be classed as = $3\frac{3}{4}$ singles, running 2100 yds. to the lb. The weight of the 160,246 yds. required will thus be $76\frac{1}{2}$ lb., which, at 2s. 1d. per lb. = £7 19s. 4d.

The ground weft is No. 8, running 4480 yds. to the lb., so the 160,246 yds. will weigh $33\frac{1}{4}$ lb., and cost, at 1s. 10d. per lb., £3 1s.

The back weft is No. 6, running 3360 yds. to the lb., the 160,246 yds. thus weighing $47\frac{3}{4}$ lb., and costing, at 1s. 10d. per lb., £4 7s. 8d.

Sizing, beaming, etc., cost $\frac{1}{12}$d. per 1000 yds. of warp yarn, *i.e.*, $(178{\cdot}500 + 171{\cdot}500) \times \frac{1}{12}$d. = 2s. 5d.

Tying up, at $\frac{3}{4}$d. per 100 ends, costs 2s. 2d.

Weaving costs $1\frac{3}{4}$d. per 1000 picks, and, as the total number of picks amounts to $70308 \times 3 = 210924$ picks, the cost will be £1 10s. 9d.

Nopping and mending = 10s. the two pieces.

Finishing costs $5\frac{7}{8}$d. per yd. of net length. Now the web measures 93 yds., but shrinks 15 per cent. in milling, and, therefore, loses $\frac{15 \times 93}{100} = 14$ yds., leaving the net length $93 - 14 = 79$ yds., which, at $5\frac{7}{8}$d. per yd. = £1 18s. 8d.

Tabulated the calculation reads :—

	£	s.	d.
Cost of face warp and selvage . .	1	8	6
Loss, 3 per cent.	0	0	9
Back warp	2	4	4
Loss, 4 per cent.	0	1	9
Pile weft	7	19	4
Loss, 4 per cent.	0	6	4
Ground weft	3	1	0
Loss, 4 per cent.	0	2	5
Back weft	4	7	8
Loss, 4 per cent.	0	3	6
Sizing, beaming, etc.	0	2	5
Add 120 per cent.	0	2	11
Tying up	0	2	2
Weaving	1	10	9
Add 70 per cent.	1	1	6
Nopping and mending	0	10	0
Add 40 per cent.	0	4	0
Finishing	1	18	8
Add 50 per cent.	0	19	4
Total for raw material, labour, etc. .	26	7	4
Sundry additions as specified, 26 per cent.	6	16	0
	33	3	4
Add for discount, 6 per cent. . . .	2	0	0
Total	35	3	4

The 79 yds. of finished cloth may, therefore, be sold at $703 \div 79 =$ 8s. 10½d. per yd., less 6 per cent.

Example 8.—Calculation for a fine, wool-dyed overcoating (Montagnac), woven as per plan in Fig. 31, from the following data :—

Number of warp ends, 2850.

,, ,, selvage ends, $20 \times 2 = 40$.

Width of web in loom, 76 ins. between selvages.

Length of warp, 100 yds.

Reed, $12\frac{1}{2}$ three-end dents per inch.
Number of picks, $52\frac{1}{2}$ per inch.
Warp yarn, No. 14, at 1s. 7d. per lb.
Effect or cashmere weft, No. 9, wound double, at 6s. 5d. per lb.
Middle weft, No. $9\frac{1}{2}$, at 1s. 8d. per lb.
Back weft, No. 4, at 1s. 10d. per lb.
Ratio of picks, 1 : 1 : 1.
Selvage yarn, No. $10\frac{1}{2}$/2's, at 1s. per lb.
Loss of warp in beaming and weaving, 4 per cent.
,, cashmere weft in winding and weaving, 5 per cent.
,, other wefts, 4 per cent.

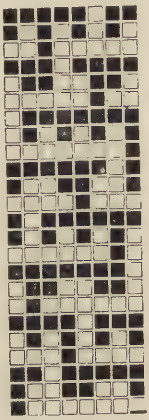

FIG. 31.

Warp contraction in the loom, 7 per cent.
Shrinkage in milling, etc., 15 per cent.
Cost of sizing, beaming, etc., $\frac{1}{16}$d. per 1000 yds. of warp.
Add 120 per cent.
Tying up, $\frac{5}{8}$d. per 100 ends.
Weaving, $1\frac{3}{4}$d. per 1000 picks.
Add 70 per cent., including cost of double winding.
Nopping and mending, 10s. the two pieces.
Finishing, $7\frac{1}{4}$d. per yd. of net length.
Add 50 per cent.
Other contingencies, 26 per cent., as in Example 7.

The warp ends, numbering 2850 and measuring 100 yds. each, will require 285,000 yds. of yarn. The count is No. 14, running 7840 yds. to the lb., so that the 285,000 yds. weigh $36\frac{1}{2}$ lb., which, at 1s. 7d. per lb. = £2 17s. 9d. There are 40 ends of selvage yarn, or 4000 yds. of No. $10\frac{1}{2}/2$'s = $5\frac{1}{4}$ singles at 2940 yds. to the lb. = 4000 ÷ 2940 = $1\frac{1}{2}$ lb., which at 1s. = 1s. 6d.

The weft setting is $52\frac{1}{2}$ per inch, or 1890 per yd., divided equally in the three classes of picks, or 1890 ÷ 3 = 630 picks of each yarn. The warp contraction being 7 per cent., the length of the web will be 93 yds., so that in this length there will be 630 × 93 = 58590 picks of each class of weft. The length of each pick is 78 ins. (including selvage), *i.e.*, the 58,590 picks will consume 126,945 yds. of yarn ; but as the weft contraction is 5 per cent., the total length of each class of weft will be $\frac{126945 \times 100}{95} = 133626$ yds.

Now the cashmere weft is No. 9, wound double, and, therefore = No. $4\frac{1}{2}$, which, at 2520 yds. per lb., will give 133626 ÷ 2520 = 53 lb., which, at 6s. 5d. per lb., will cost £16 14s. 7d.

The middle weft is No. $9\frac{1}{2}$, running 5320 yds. to the lb. and weighing 133626 ÷ 5320 = $25\frac{1}{4}$ lb., which, at 1s. 8d. per lb. = £2 2s. 2d.

The back weft is No. 4, running 2240 yds. to the lb. and weighing 133626 ÷ 2240 = $59\frac{3}{4}$ lb., which, at 1s. 10d. per lb. = £5 9s. 6d.

Sizing, beaming, etc., cost $\frac{1}{16}$d. per 1000 yds. of warp yarn, *i.e.*, 285 × $\frac{1}{16}$d. = 1s. 6d. To this must be added 120 per cent. as before = 1s. 9d.

Tying up costs $\frac{5}{8}$d. per 100 ends, *i.e.*, 28·50 × $\frac{5}{8}$d. = 1s. 6d.

Weaving = $1\frac{3}{4}$d. per 1000 picks, *viz.*, $58590 \times 3 = \frac{175770 \times 1\frac{3}{4}}{1000}$ = £1 5s. 7d. The added 70 per cent. for double winding, etc., = 18s.

Nopping and mending cost 10s. the two pieces.

Finishing = $7\frac{1}{4}$d. per yd. of net length. The web shrinks 15

per cent. in finishing, and, therefore, the 93 yds. will lose $\frac{15 \times 93}{100}$ = 14 yds., leaving a net length of 93 − 14 = 79 yds., which, at 7¼d. per yd. = £2 7s. 9d.

The results of the calculation are, therefore :—

	£	s.	d.
Cost of warp yarn	2	17	9
Loss in beaming and weaving, 4 per cent.	0	2	4
Selvage yarn	0	1	6
Cashmere weft	16	14	7
Loss in winding and weaving, 5 per cent.	0	16	9
Middle weft	2	2	2
Loss, 4 per cent.	0	1	8
Back weft	5	9	6
Loss, 4 per cent.	0	4	5
Sizing and beaming warp . . .	0	1	6
Add 120 per cent.	0	1	9
Tying up	0	1	6
Weaving	1	5	7
Add 70 per cent.	0	18	0
Nopping and mending	0	10	0
Finishing	2	7	9
Add 50 per cent.	1	3	11
Cost of material, labour, etc. . .	35	0	8
Add 26 per cent.	9	2	0
Together . . .	44	2	8
Discount, 6 per cent.	2	13	0
Total	46	15	8

The 79 yds. of cloth may, therefore, be sold at £46 15s. 8d. ÷ 79 = 11s. 10⅛d. per yd., less 6 per cent. discount.

EXAMPLE 9.—Calculation of a fine, piece-dyed, thirteen-shaft corkscrew worsted fabric (weave Fig. 32) from the following particulars :—

Number of warp ends, 6266.

Number of selvage ends, 50 × 2 = 100 of similar yarn.
Width of web in loom, 68 ins. between selvages.
Reed, $21\frac{1}{4}$ dents (4, 4 and 5 ends), per inch.
Length of warp, 100 yds. per two pieces.
Number of picks per inch, 104.
Warp yarn, No. 56/2's, at 3s. per lb.
Weft yarn, No. $63\frac{1}{2}$/2's, at 3s. 2d. per lb.
Loss of warp and weft in beaming and weaving, $2\frac{1}{2}$ per cent.
Warp contraction in the loom, 7 per cent.
Shrinkage in finishing, 5 per cent.
Loss of weight in finishing, 9 per cent.
Cost of sizing, beaming, etc., $\frac{1}{16}$d. per 1000 yds. of warp.
Add 120 per cent.

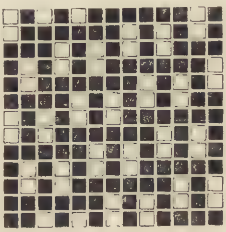

FIG. 32.

Tying up, $\frac{5}{8}$d. per 100 warp ends.
Weaving, $1\frac{1}{2}$d. per 1000 picks.
Add $66\frac{2}{3}$ per cent.
Nopping and mending, 11s. the two pieces.
Add 40 per cent.
Finishing, 3d. per yd. net length.
Add 50 per cent.
Carbonising, etc., 7s. the two pieces.
Dyeing, $2\frac{1}{4}$d. per lb.
The supplementary additions include :—
For delays in payment, 2 per cent.
Agents and commission, 2 per cent.
Samples, 2 per cent.

Loss of interest on material during manufacture, 2 per cent.

Eventual rise in cost of materials, 2 per cent.

Defective pieces, $\frac{1}{2}$ per cent.

Overmeasure, $\frac{1}{2}$ per cent.

Banker's discount and charges, insurances, sick fund, general and petty expenses, 5 per cent.

Freight and packing, 1 per cent.

Profit, 8 per cent.

Discount, 6 per cent.

There are 6266 warp ends and 100 selvage threads of the same yarn, or 6366 ends of 100 yds. each = 636,600 yds.

The warp yarn is No. 56/2's = No. 28 singles, running 15,680 yds. to the lb. and weighing 636600 ÷ 15680 = $40\frac{3}{4}$ lb., which at 3s. per lb. = £6 0s. 3d.

There are 104 picks per inch or 3744 per yard. Since the warp contracts 7 per cent in the loom, the web will measure 93 yds. and the number of picks will be 93 × 3744 = 348192. Each pick is 68 ins. + 2 ins. = 70 ins. long, so the 348,192 picks will consume 677,040 yds. of yarn, but since the weft contraction is 5 per cent. in the loom, the actual length of yarn required will be $\frac{677040 \times 100}{95} = 712673$ yds.

The yarn is No. $63\frac{1}{2}$/2's = No. $31\frac{3}{4}$ singles, running 17,780 yds. to the lb., and weighing 712673 ÷ 17780 = $45\frac{3}{4}$ lb., which at 3s. 2d. per lb. = £7 4s. 11d.

Sizing, beaming, etc., cost $\frac{1}{16}$d. per 1000 yds. of warp yarn, so that the 636,600 yds. of warp yarn will cost on this score 3s. 4d.

Add 120 per cent. = 4s.

Tying up at $\frac{5}{8}$d. per 100 ends = 63·66 × $\frac{5}{8}$d. = 3s. 4d.

Weaving costs $1\frac{1}{2}$d. per 1000 picks, *i.e.*, 386·88 × $1\frac{1}{2}$d. = £2 8s. 4d.

Add $66\frac{2}{3}$ per cent. = £1 12s. 2d.

Nopping and mending = 11s. the two pieces.

Add 40 per cent. = 4s. 5d.

Finishing costs 3d. per yard of net length. Since the goods shrink 5 per cent. in finishing, the 93 yds. of web will lose

$\frac{5 \times 93}{100} = 4{\cdot}65$ yds., leaving $93 - 4{\cdot}65 = 88{\cdot}35$ or $88\frac{1}{4}$ yds., which at 3d. per yd. = £1 2s.

Add 50 per cent. = 11s.

Carbonising, etc. = 7s. the two pieces.

Dyeing costs $2\frac{1}{4}$d. per lb. of finished cloth.

Now the warp yarn weighs	$40\frac{3}{4}$ lb.
,, weft ,, ,, ...	$45\frac{3}{4}$,,
Together	$86\frac{1}{2}$ lb.

The loss of weight in finishing is 9 per cent or $7\frac{3}{4}$ lb., leaving $78\frac{3}{4}$ lb. as the net weight. This at $2\frac{1}{4}$d. per lb. = 14s. 9d.

Tabulated, these results read :—

	£	s.	d.
Cost of warp and selvage yarn . .	6	0	3
Loss in beaming and weaving, $2\frac{1}{2}$ per cent.	0	3	0
Weft yarn	7	4	11
Loss in weaving, $2\frac{1}{2}$ per cent. . .	0	3	8
Beaming, etc.	0	3	4
Add 120 per cent.	0	4	0
Tying up	0	3	4
Weaving	2	8	4
Add $66\frac{2}{3}$ per cent.	1	12	2
Nopping and mending	0	11	0
Add 40 per cent.	0	4	5
Finishing	1	2	0
Add 50 per cent.	0	11	0
Carbonising	0	7	0
Dyeing	0	14	9
Cost of material, labour, etc. . .	21	13	2
Add 25 per cent., including profit but not discount	5	8	4
Total	27	1	6
Discount, 6 per cent.	1	12	6
Total	28	14	0

The $88\frac{1}{4}$ yds. may therefore be sold at £28 14s. ÷ $88\frac{1}{4}$ = 6s. $6\frac{1}{16}$d. per yd., less 6 per cent. discount.

EXAMPLE 10.—Calculation of wool-dyed worsted fabric (weave, Fig. 33) from the following data:—

Number of warp ends, 4950.

Number of cotton selvage ends, $2 \times 40 = 80$.

Width of web in loom, 66 ins. between selvages.

Reed, 15 four-end dents per inch.

Warp length, 100 yds. for two pieces.

Number of picks, 80 per inch.

Warp yarn, No. 49/2's, at 3s. per lb.

Weft yarn, No. $24\frac{1}{2}$ singles, at 2s. 9d. per lb.

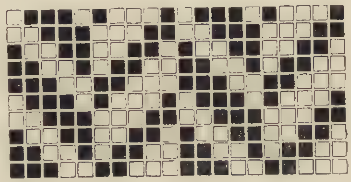

FIG. 33.

Loss of warp and weft yarn in beaming and weaving, $2\frac{1}{2}$ per cent.

Selvage yarn, No. $35\frac{1}{2}$/2's, at 11d. per lb.

Warp contraction in weaving, 7 per cent.

Shrinkage of web in finishing, $6\frac{1}{2}$ per cent.

Sizing, beaming, etc., $\frac{1}{16}$d. per 1000 yds. of warp.

Add 120 per cent. for sundries.

Tying up $\frac{5}{8}$d. per 100 warp ends.

Weaving, $1\frac{1}{2}$d. per 1000 picks.

Add $66\frac{2}{3}$ per cent. for sundries.

Nopping and mending, 10s. the two pieces.

Add 40 per cent.

Finishing, spotting out, and obliterating stripes, $2\frac{3}{4}$d. per yard.

Add 50 per cent.

Further additions for contingencies :—

For delays in payment, 2 per cent.

Agents and commission, 2 per cent.

Samples, 2 per cent.

Loss of interest on material during manufacture, 2 per cent.

Rise in price of material, 2 per cent.

Defective pieces, $\frac{1}{2}$ per cent.

Overmeasure, $\frac{1}{2}$ per cent.

Banker's discount and charges, loss in exchange, various insurances, sick fund, general, and petty expenses, 5 per cent.

Profit, 8 per cent.

Discount, 6 per cent.

There are 4950 warp ends of 100 yds. each = 495,000 yds. of warp yarn, No. 49/2's = $24\frac{1}{2}$ singles, running 13,720 yds. per lb., and therefore weighing $495000 \div 13720 = 36\frac{1}{8}$ lb., which at 3s. per lb. = £5 8s. 4d.

The 80 ends of selvage are No. $35\frac{1}{2}$/2's cotton yarn = No. $17\frac{3}{4}$ singles, running 14,910 yds. to the lb. and weighing $\frac{9}{16}$ lb., which at 11d. per lb. = 6d.

There are 80 picks per inch or 2880 per yard, which in 93 yds. of web = 267,840 picks. Each pick measures 66 ins. + 2 ins. (selvages) = 68 ins., and therefore the 267,840 picks will consume 505,920 yds. of weft. Owing, however, to the 5 per cent. contraction in the loom, the actual length of weft yarn required will be $\frac{505920 \times 100}{95} = 532547$ yds. The yarn is No. $24\frac{1}{2}$ singles at 13,720 yds. per lb., and will weigh $532547 \div 13720 = 40\frac{1}{8}$ lb., which at 2s. 9d. per lb. = £5 10s. 4d.

Sizing, beaming, etc., cost $\frac{1}{16}$d. per 1000 yds. of warp, *i.e.*, $495 \times \frac{1}{16}$d. = 2s. 7d. The additional 120 per cent. = 3s. 1d.

Tying up at $\frac{5}{8}$d. per 100 ends = $49{\cdot}5 \times \frac{5}{8}$d. = 2s. 7d.

Weaving costs $1\frac{1}{2}$d. per 1000 picks, or $267{\cdot}840 \times 1\frac{1}{2}$d. = £1 13s. 6d. The additional $66\frac{2}{3}$ per cent. = 22s. 4d.

Nopping and mending, 10s. the two pieces, and the 40 per cent. additional = 4s.

Finishing costs $2\frac{3}{4}$d. per yard of finished cloth. Now the

web measures 93 yds. and loses $6\frac{1}{2}$ per cent. in finishing, so that it will be reduced by $\frac{6\frac{1}{2} \times 93}{100} = 6$ yds., and the net length will therefore be 87 yds., which at $2\frac{3}{4}$d. per yard = £1. The 50 per cent. additional = 10s.

Our calculations can be tabulated as follows :—

	£	s.	d.
Cost of warp yarn	5	8	4
Loss, $2\frac{1}{2}$ per cent.	0	2	9
Selvage yarn	0	0	6
Weft yarn	5	10	4
Loss, $2\frac{1}{2}$ per cent.	0	2	9
Sizing, beaming, etc.	0	2	7
Add 120 per cent.	0	3	1
Tying up	0	2	7
Weaving	1	13	6
Add $66\frac{2}{3}$ per cent.	1	2	4
Nopping and mending	0	10	0
Add 40 per cent.	0	4	0
Finishing	1	0	0
Add 50 per cent.	0	10	0
	16	12	9
Add for sundries, except discount, 25 per cent.	4	3	1
Together.	20	15	10
Discount, 6 per cent.	1	5	0
Total	22	0	10

The 87 yds. of finished cloth may, therefore, be sold at £22 0s. 10d. ÷ 87 = 5s. 1d. per yd., less 6 per cent. discount.

Example 11.—Calculation of fabrics when all the operations except nopping and mending are let out at fixed rates.

Let us take the case of a maker turning out 800 pieces, of 43-45 yds. each, per annum.

The staff will consist of :—

		£	s.	
1. A manager and designer . .	salary	180	0	per ann.
2. A weaving foreman who gives out the yarn	,,	75	0	,,
3. A clerk, who also looks after the stores	,,	60	0	,,
4. An assistant storekeeper, messenger and packer	,,	46	16	,,
5. A mending forewoman who works with the	,,	57	10	,,
6. Four menders (females) who also do the nopping, at 16s. a week each	,,	166	8	,,
Total		585	14	per ann.

General expenses :—

	£	s.
Accident insurance, sick fund, etc.	6	5
Fire insurance	16	0
Rent	60	0
Coal and fires	10	0
Lighting	10	0
Stamps and telegrams	25	0
Telephone	7	10
Account books, stationery, etc.	5	10
Sample books for store	0	10
Depreciation and maintenance of furniture . . .	4	0
Packing paper, mill board, cloth and string . .	9	0
Cleaning premises	5	0
Sewing and mending silk	1	0
Contingencies	10	0
	169	15
Expenses of staff as above	585	14
Total current expenditure . .	755	9

or £755 9s. per annum

The annual output being 800 pieces of cloth, the average share of these expenses per piece will be $15109 \div 800 = 18$s. 10d.

The influence of this charge will of course vary according to the quality of the goods produced and the number of pieces turned out in a year. It will also vary according to the amount of salaries that must be paid to secure a competent staff, the outlay for rent, and so on, and the actual figures will have to be determined separately by each manufacturer.

To illustrate the incidence of the charge in question we will take two examples.

EXAMPLE 1.—A good class wool-dyed worsted containing silk in the warp, woven as per plan, Fig. 34, and made up as follows:—

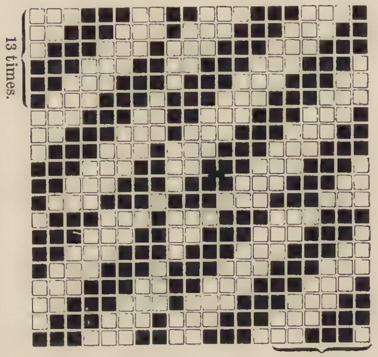

FIG. 34.

Number of warp ends, 5440.

Number of selvage ends, $2 \times 50 = 100$.

Width of web in loom, 64 ins. between selvages.

Reed, 21¼ four-end dents per inch.

Warp yarn, twist composed of one end black worsted yarn, No. 24½, at 3s. per lb., and one white silk thread (organzine) 227,000 yds. to the lb., at £2 2s. 6d. per lb.

Weft, black worsted yarn, No. 24½, at 3s. per lb.

Selvage, No. 35½/2's, at 1s. 1d. per lb.

Doubling costs 3½d. per lb.

Number of picks per inch, 90.

Contraction in the loom, 6 per cent.

Weft contraction in the loom, 5 per cent.

Loss of warp in doubling, beaming and weaving, $3\frac{1}{2}$ per cent.

Loss of weft in weaving, $2\frac{1}{2}$ per cent.

Shrinkage in finishing, 5 per cent.

Sizing, beaming, etc., $\frac{5}{32}$d. per 1000 yds. of warp.

Tying up, $\frac{5}{8}$d. per 100 ends.

Weaving, $2\frac{3}{8}$d. per 1000 picks.

Nopping and mending. Done on the premises and included in general expenses.

Finishing, $3\frac{1}{2}$d. per yard of nett length.

Contingent expenses :—

For overdue accounts, 2 per cent.

Agents and commission, 2 per cent.

Samples, 2 per cent.

Loss of interest on cost of material during manufacture, 2 per cent.

Defective pieces, $\frac{1}{2}$ per cent.

Overmeasure, $\frac{1}{2}$ per cent.

Current expenses, 18s. 10d. per piece.

Profit, 10 per cent.

Discount, 6 per cent.

The warp ends number 5440 of 100 yds. each, or 544,000 yds. in all.

The yarn is doubled, consisting of a No. $24\frac{1}{2}$ black worsted and a white organzine at 227,000 yds. per lb. The black yarn runs 13,720 yds. to the lb., so that the 544,000 yds. weigh $39\frac{5}{8}$ lb., which at 3s. per lb. = £5 18s. 11d.

The silk runs 227,000 yds. to the lb., and therefore weighs 2·4 lb., which at £2 2s. 6d. per lb. = £5 2s.

The total warp yarn weighs—

Black yarn	39·6 lb.
Silk yarn	2·4 ,,
	42 lb.

Doubling costs $3\frac{1}{2}$d. per lb., or 42 × $3\frac{1}{2}$d. = 12s. 3d.

Hence the total cost of the warp yarn is :—

	£	s.	d.
Black yarn	5	18	11
Silk yarn	5	2	0
Doubling	0	12	3
	11	13	2

The selvage ends number $2 \times 50 = 100$ of 100 yds. each, or 10,000 yds. in all. The yarn is No. $35\frac{1}{2}/2$'s cotton, running 14,910 yds. to the lb., and weighing $10000 \div 14910 = 10\frac{3}{4}$ oz., which at 1s. 1d. per lb. = 10d.

The number of picks is 90 per inch or 3240 per yard. Since the warp contracts 6 per cent. in the loom, the web will measure $100 - 6 = 94$ yds. This will give $94 \times 3240 = 304560$ picks in all. Each pick measures 64 ins. + 2 ins. (selvage) = 66 ins., and the length of yarn consumed by the 304,560 picks will be 558,360 yds.

However, since the weft contracts 5 per cent. in the loom, the total length of weft yarn required will be

$$\frac{558360 \times 100}{94} = 587747 \text{ yds.}$$

The weft yarn is No. $24\frac{1}{2}$, running 13,720 yds. to the lb., and therefore weighing $587747 \div 13720 = 42\frac{1}{8}$ lb., which at 3s. per lb. = £6 6s. 4d.

Sizing, beaming, etc., cost $\frac{5}{32}$d. per 1000 yds. of warp, *i.e.*, $544 \times \frac{5}{32}$d. = 7s. 1d.

Tying up costs $\frac{5}{8}$d. per 100 ends, or for 5440 ends, 2s. 10d.

Weaving costs $2\frac{3}{8}$d. per 1000 picks, so that the 304560 picks will cost on this head, £3 0s. 3d.

Nopping and mending are done on the premises, and the cost is included in the general expenses.

Finishing costs $3\frac{1}{2}$d. per yard of nett length.

The web measures 94 yds. but loses 5 per cent. by shrinkage during finishing, and is therefore shortened by $\frac{5 \times 94}{100} = 4\frac{3}{4}$ yds., leaving $94 - 4\frac{3}{4} = 89\frac{1}{4}$ yds. net, which at $3\frac{1}{2}$d. = £1 6s.

Tabulated, therefore, the calculation reads :—

	£	s.	d.
Cost of warp yarn	11	13	2
Loss, $3\frac{1}{2}$ per cent.	0	8	2
Selvage	0	0	10
Weft	6	6	4
Loss, $2\frac{1}{2}$ per cent.	0	3	2
Sizing, beaming, etc.	0	7	1
Tying up	0	2	10
Weaving	3	0	3
Finishing	1	6	0
Direct outlay	23	7	10
Add for contingencies and profit but exclusive of discount, 22 per cent. .	5	3	0
Current expenses, 18s. 10d. per piece .	1	17	8
Total	30	8	6

In addition we have to reckon 6 per cent. on the above sum, for discount = £1 16s. 6d., bringing up the total to £32 8s. Since the two pieces measure $89\frac{1}{4}$ yds., the goods may be sold at 7s. $3\frac{1}{8}$d. per yard, less 6 per cent. discount.

In the above instance the profit was fixed at 10 per cent.; but in the case of better made goods, *i.e.*, where the expense of samples comes higher, or there is a risk of some of the goods having to be sold afterwards at a great reduction, one is compelled to cover the risk by a larger margin of profit. For new and peculiar styles, the prices paid are, often enough, much higher than those for stock goods.

Example 2. — Calculation of a superior multi-coloured worsted fabric (weave, Fig. 27), from the following specification :—

Number of warp ends, 7680.
Selvage, as in preceding example.
Reed, 15 eight-end dents per inch.
Width in loom, 64 ins. between selvages.
Warp length, 100 yds. for two pieces.

Three classes of warp and weft yarns are used, A, B, and C.

A is black twist, No. 49/2's.

B consists of a black, No. 49 singles, twisted with a light grey, No. 63 singles.

C consists of a black, No. 28 singles, twisted with a red chappe silk, running 91,000 yds. to the lb.

A costs 3s. per lb.; B = 3s. 1d. per lb.

C is to be doubled on the premises, the black yarn costing 2s. 9d. per lb., and the chappe silk, 16s. per lb. For A and B an allowance is made of $2\frac{1}{2}$ per cent. loss in beaming and weaving, and $3\frac{1}{2}$ per cent. for C.

The warp draft is as follows :—

60 {	6	ends of	yarn	A,
	6	,,	,,	B,
	2	,,	,,	C,
	4	,,	,,	A,
	6	,,	,,	B,
60 {	6	,,	,,	A,
	6	,,	,,	B,
48 {	4	,,	,,	A,
	2	,,	,,	B,
	2	,,	,,	A,
	4	,,	,,	B,
	2	,,	,,	C,
	2	,,	,,	A,
	2	,,	,,	B,
	2	,,	,,	A,
	4	,,	,,	B,
48 {	4	,,	,,	A,
	2	,,	,,	B,
	2	,,	,,	A,
	4	,,	,,	B,

Together 240 ends per repeat.

The weft yarn corresponds exactly with the face of the warp, but only half as many threads of each kind of yarn are taken.

Doubling yarn, C, costs $3\frac{1}{2}$d. per lb.

Number of picks per inch, 60.

Warp contraction in the loom, 7 per cent.

Weft contraction in the loom, 5 per cent.

Shrinkage in finishing, 3 per cent.

Sizing, beaming, etc., cost for this complicated pattern, $\frac{3}{16}$d. per 1000 yds. of warp yarn.

Tying up, $\frac{3}{4}$d. per 100 ends.

Weaving, $2\frac{1}{2}$d. per 1000 picks.

Nopping and mending, as in previous example.

Finishing costs 3d. per yard.

All other contingencies, current expenses, profit and discount, as in previous example.

There are 7680 warp ends, and as each repeat contains 240 ends, the number of repeats in the full width will be

$$7680 \div 240 = 32.$$

Each repeat contains 116 ends of warp A,
120 ,, ,, B,
4 ,, ,, C,

240 ends.

or in the full width :—

A $116 \times 32 = 3712$ ends.
B $120 \times 32 = 3840$,,
C $4 \times 32 = 128$,,

Together 7680 ends.

Of class A there are 3712 ends of 100 yds. = 371,200 yds. in all. The yarn is No. 49/2's = No. $24\frac{1}{2}$ singles, running 13,720 yds. to the lb., and weighing 27 lb., which at 3s. per lb. = £4 1s.

Of yarn B there are 3840 ends of 100 yds. = 384,000 yds. in all. This yarn consists of a No. 49 black yarn and No. 63 grey, the yarn number being therefore $\frac{49 \times 63}{49 + 63} = 27\frac{3}{4}$, and running 15,540 yds. to the lb. Hence the weight of the 384,000 yds. is $24\frac{3}{4}$ lb., which at 3s. 1d. per lb. = £3 16s. 4d.

Of yarn C there are 128 warp ends of 100 yds. = 12,800 yds. The yarn is composed of one end of black No. 28 singles, and one end of chappe silk 91,000 yds. to the lb., so that 12,800 yds. of each are required for the 128 ends.

The black yarn runs 15,680 yds. to the lb., and therefore weighs 12800 ÷ 15680 = 0·8 lb., which at 2s. 9d. per lb. = 2s. 3d.; whilst the chappe silk weighs 12800 ÷ 91000 = 0·14 lb., which at 16s. per lb. = 2s. 3d.

The weight of the two together is 0·8 + 0·14 = 0·94 lb., and costs for doubling at $3\frac{1}{2}$d. per lb. = $3\frac{1}{2}$d., the total cost of the 12,800 yds. of doubled yarn being therefore 2s. 3d. + 2s. 3d. + $3\frac{1}{2}$d. = 4s. $9\frac{1}{2}$d.

The selvage, as in the previous example, costs 10d.

Of weft yarn there are 60 picks per inch, or 2160 per yard. The warp contracts 7 per cent. in weaving, so the web measures 93 yds., and requires 93 × 2160 = 200880 picks.

The various classes of weft are inserted in the same order as the warps, except that there are in this case only half as many threads to a repeat, *viz.*, 120 instead of 240. The number of repeats in the length is therefore 200880 ÷ 120 = 1674.

In the warp we have 116 ends of yarn A per repeat; hence there will be only 58 in the weft, or a total of 1674 × 58 = 97092 picks in all. Each pick measures 64 ins. + 2 ins. (selvages) = 66 ins., and the 97,092 picks therefore measure 178,002 yds. of weft A. Allowing 5 per cent. for contraction in the loom, this figure is increased to $\frac{178002 \times 100}{95}$ = 187370 yds.

The yarn (No. 49/2's) runs 13,720 yds. to the lb., and therefore 187,370 yds. weigh $13\frac{5}{8}$ lb., which at 3s. per lb., = £2 0s. 10d.

Of weft B there are 120 ÷ 2 = 60 picks per repeat, or 1674 × 60 = 100440 in all, the length being 100,440 × 66 ins. = 184140 yds., or allowing for the 5 per cent. contraction, $\frac{184140 \times 100}{95}$ = 193830 yds. This yarn is No. $27\frac{3}{4}$, running 15,540 yds. to the lb., and thus weighs 193830 ÷ 15540 = $12\frac{1}{2}$ lb., which at 3s. 1d. per lb. = £1 18s. 6d.

Of weft C there are only two ends in each repeat, or $1674 \times 2 = 3348$ in all. Each pick is 66 ins. long, the length of the 3348 being therefore 6138 yds., or allowing for the 5 per cent. contraction $\frac{6138 \times 100}{95} = 6461$ yds.

We thus require 6461 yds. of black yarn and the same quantity of chappe silk. The black runs 15,680 yds., to the lb. and weighs $6461 \div 15680 = 0{\cdot}412$ lb., which at 2s. 9d. per lb. = 1s. $1\frac{1}{2}$d. The chappe silk weighs $6461 \div 91000 = 0{\cdot}071$ lb., which at 16s. per lb. = 1s. $1\frac{1}{2}$d.

The weight of the two together is $0{\cdot}412 + 0{\cdot}071 = 0{\cdot}483$ lb., which costs for doubling at $3\frac{1}{2}$d. per lb., $1\frac{1}{2}$d. The full cost of the yarn C is therefore 1s. $1\frac{1}{2}$d. + 1s. $1\frac{1}{2}$d. + $1\frac{1}{2}$d. = 2s. $4\frac{1}{2}$d.

Sizing, beaming, etc., costs $\frac{3}{16}$d. per 1000 yds. of warp, *i.e.*, $768 \times \frac{3}{16}$d. = 12s.

Tying up costs $\frac{3}{4}$d. per 100 ends, *i.e.*, $76{\cdot}8 \times \frac{3}{4}$d. = 4s. 8d.

Weaving costs $2\frac{1}{2}$d. per 1000 picks, or $200{\cdot}880 \times 2\frac{1}{2}$d. = £2 1s. 10d.

Nopping and mending are done at home, and are included in the general expenses.

Finishing costs 3d. per yard net length. The web measures 93 yds. but shrinks 3 per cent. in finishing, and therefore loses $2\frac{3}{4}$d yds., leaving $93 - 2\frac{3}{4} = 90\frac{1}{4}$ yds. as the net length. This at 3d. = £1 2s. 7d.

The calculation may be tabulated as under :—

	£	s.	d.
Cost of warp yarn, A and B . .	7	17	4
Loss, $2\frac{1}{2}$ per cent.	0	3	11
Warp C	0	4	$9\frac{1}{2}$
Loss, $3\frac{1}{2}$ per cent.	0	0	2
Selvage	0	0	10
Weft yarn A and B	3	19	4
Loss, $2\frac{1}{2}$ per cent.	0	2	0
Weft C	0	2	$4\frac{1}{2}$
Loss, $3\frac{1}{2}$ per cent.	0	0	1
Sizing, beaming, etc.	0	12	0
Tying up	0	4	8
Weaving	2	1	10
Finishing	1	2	7
Together	16	11	11
Other expenses same as in preceding example, *i.e.*, 22 per cent. . .	3	12	10
Current expenses at 18s. 10d. per piece .	1	17	8
	22	2	5
Add for discount, 6 per cent. . .	1	6	7
Total	23	9	0

The $90\frac{1}{4}$ yds. of finished cloth may therefore be sold at 5s. $2\frac{3}{8}$d. per yard, less 6 per cent. discount.

SECTION III. (*Continued*).

CHAPTER V.

CALCULATION OF FABRICS BEFOREHAND TO MATCH SAMPLES.

As already mentioned, it was formerly the practice to make the goods first and reckon the cost afterwards. This is now rarely done; and it is a frequent occurrence for the manufacturer to receive orders or samples from buyers, in respect of which he is compelled to make calculations without any actual data. Of course it is essential in such cases that he should be perfectly clear as to what material he may use for warp and weft, how many ends and picks can be set to the inch, and what the various operations will cost. With a sample, even of a competitor's goods, the task is lighter, it being then easier to determine the quality and quantity of the yarns and what processes the goods must be put through.

A more difficult state of things arises when a given class of goods costing a certain price is to be produced at a cheaper rate. In such event it will be the manufacturer's task to first see what economies he can effect in the cost of the material, either by buying to advantage or introducing a lower quality, and then turn his attention to reducing the cost of production, whether by using improved machinery of higher productive capacity, seeking out a spot where cheaper power and labour are available, etc., etc.

THE END.

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